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**FINAL**  
**REMEDIAL INVESTIGATION REPORT**

**JOHNS-MANVILLE DISPOSAL AREA  
WAUKEGAN, ILLINOIS**

**VOLUME I**

**JULY, 1985**



**KUMAR MALHOTRA & ASSOCIATES, INC.**  
**ENGINEERS • CONSULTANTS • PLANNERS**  
Grand Rapids, Michigan/Monroe, Wisconsin

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**REMEDIAL INVESTIGATION REPORT**

**JOHNS-MANVILLE DISPOSAL AREA  
WAUKEGAN, ILLINOIS**

**VOLUME I**

**JULY, 1985**

Manville Service Corporation  
Ken-Caryl Ranch  
Denver, Colorado 80217  
303 978-2000

# Manville

July 3, 1985

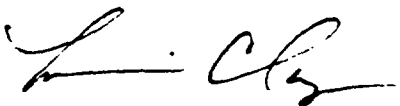
Mr. Rodney Gaither  
Project Coordinator  
U.S. Environmental Protection Agency  
Region V  
230 South Dearborn Street  
Chicago, Illinois 60604

Re: Johns-Manville Waukegan Disposal Area RI/FS

Dear Mr. Gaither:

In accordance with the terms and conditions of the Administrative Order by Consent entered into between Johns-Manville Sales Corporation ("J-M") and the United States Environmental Protection Agency ("USEPA"), J-M is hereby submitting two copies of the final Remedial Investigation Report on the Johns-Manville Waukegan Disposal Area. A technical memorandum covering the air monitoring for lead, additional water quality data and re-evaluation of the risk to human health and environment will be submitted for your review by September 15, 1985. Please feel free to contact me if you have any questions on the contents of this report.

Sincerely,



Marvin Clumpus, P.E.  
Project Coordinator

cc: Basil G. Constantelos, USEPA (w/enclosure)  
Chrono/File



• ENGINEERS • CONSULTANTS • PLANNERS •

KUMAR MALHOTRA & ASSOCIATES INC

3000 East Belt Line N.E.  
Grand Rapids, Michigan 49505  
Telephone (616) 361-5092

July 3, 1985

Mr. James H. Whipple  
Senior Staff Engineer  
Manville Service Corporation  
Ken-Caryl Ranch  
Denver, Colorado 80217

Dear Jim:

This final remedial investigation report documents the procedures and results of the detailed site characterization studies conducted to date. This report also contains an endangerment assessment of the site based on the existing and additional data obtained during the site characterization studies. The response to the USEPA review comments on the draft RI report have been included, where appropriate. Additional data on monitoring air for lead and water quality will be obtained during the months of July and August, 1985. This data will be used to reevaluate the risk to human health and environment, and the findings presented in the form of a Technical Memorandum for review of USEPA by September 15, 1985. A brief description of these investigations is included in Appendix K, Volume II of the final RI Report.

If you have any questions please call me at (616) 361-5092.

Very truly yours,

A handwritten signature in cursive script, reading 'S. K. Malhotra'.

S. K. Malhotra PhD., P.E.

KMA:sa

**FINAL**  
**REMEDIAL INVESTIGATION REPORT**

**JOHNS-MANVILLE DISPOSAL AREA**  
**WAUKEGAN, ILLINOIS**

**PROJECT: S94-3224**

**JULY, 1985**

**NON-DISCLOSURE STATEMENT**

This document has been prepared under contract for Johns-Manville Sales Corporation. The material contained herein is not to be disclosed to, discussed with, or made available to any person or persons for any reason without the prior expressed approval of a responsible official of the Johns-Manville Sales Corporation.

**KUMAR MALHOTRA AND ASSOCIATES, INC.**  
**CONSULTING ENGINEERS**  
**3000 EAST BELTLINE N. E.**  
**GRAND RAPIDS, MICHIGAN 49505**  
**(616) 361-5092**

## TABLE OF CONTENTS

	<u>Page</u>
1.0 EXECUTIVE SUMMARY.....	1-1
1.1 Site Investigations.....	1-1
1.2 Endangerment Assessment.....	1-3
1.3 Conclusions.....	1-4
2.0 INTRODUCTION.....	2-1
3.0 EXISTING DATA EVALUATION.....	3-1
3.1 Background Site Data.....	3-1
3.2 Environmental Setting.....	3-5
3.3 Plant Description.....	3-12
3.4 Regulations.....	3-14
3.5 Management Practices.....	3-15
4.0 REMEDIAL INVESTIGATIONS.....	4-1
4.1 Work Plan Preparation.....	4-1
4.2 Site Reconnaissance.....	4-2
4.3 Soil Sampling and Analysis.....	4-3
4.4 Monitoring Well Installation and Groundwater Movement.....	4-15
4.5 Groundwater Sampling and Analysis.....	4-22
4.6 Water Balance Studies.....	4-26
4.7 Air Sampling and Analysis (Executive Summary).....	4-28
5.0 ENDANGERMENT ASSESSMENT.....	5-1
5.1 Physical Description of the Site and Site History.....	5-1
5.2 Site Contamination/Off-Site Contamination.....	5-1
5.3 Environmental Fate and Transport.....	5-3
5.4 Toxicological Properties.....	5-4
5.5 Exposure Assessment.....	5-14

5.6	Risk Assessment.....	5-15
5.7	Conclusions.....	5-15

#### APPENDED MATERIAL

Ontario Research Foundation Report on Air Sampling and Analysis  
February, 1985 and response to USEPA comments on air monitoring  
results presented in draft RI Report.

## LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
3-1	Vicinity Map.....	3-2
3-2	Regional Location Map.....	3-3
3-3	Site Location Map.....	3-4
4-1	Boring and Monitoring Well Location Map.....	4-4
4-2	Geologic Cross Section Map.....	4-7
4-3	Water Level Data Plot.....	4-18
4-4	Water Level Data Plot.....	4-19
4-5	Water Level Data Plot.....	4-20
4-6	Geothermal Flow Map.....	4-21
4-7	Schematic Waterflow Diagram.....	4-27



## LIST OF TABLES

<u>Table</u>		<u>Page</u>
3-1	USEPA Ambient Water Quality Criteria.....	3-16
4-1	Summary of Selected Soil Samples.....	4-8
4-2	Summary of Results of Chemical Analysis.....	4-11
4-3	Summary of Engineering Properties.....	4-13
4-4	Monitoring Well Water Level Data.....	4-16
4-5	Groundwater Sample Bottles, Procedures and Preservatives.....	4-23
4-6	Groundwater Sample Field Test Results.....	4-23
4-7	Summary of Monitoring Well Test Results.....	4-25

## 1.0

### EXECUTIVE SUMMARY

This document is a Remedial Investigation ("RI") report for the Johns-Manville Disposal Area, in Waukegan, Illinois. This report presents background site information as well as details of air, soil, groundwater investigations carried out in accordance with the consent agreement between USEPA and Johns-Manville.

The information obtained has been used to interpret the nature, distribution, quantities and characteristics of on-site and off-site contaminants and to prepare an endangerment assessment of the site. The endangerment assessment presents an evaluation of the level of endangerment to human health and the environment posed by actual or potential release of hazardous substances from this site.

The information presented in this report is to provide a basis for evaluating remedial alternatives and selecting recommended remedial measures during the feasibility study.

### 1.1 SITE INVESTIGATIONS

Johns-Manville property in Waukegan, Illinois includes a disposal area for the treatment and recycling of process wastewater and disposal of solid wastes from their manufacturing facilities in Waukegan, Illinois. This site has received wastes since 1922 in the form of cuttings, residues and waste products. These wastes were reported to contain varying amounts of friable and non-friable asbestos, lead, chromium, thiram and other contaminants.

Air, soil and groundwater investigations were conducted to determine the nature and extent of existing site contamination and are summarized in this section.

#### 1.1.1. AIR INVESTIGATION

Five on-site and 3 off-site locations were used for air sampling for asbestos fiber counts. Five test runs were conducted, each for a period of about 12 hours. Windspeed and direction was recorded during sampling intervals. The nearest off-site location was in the residential area closest to the site, approximately 1.0 mile from the site. Samples were analyzed by transmission electron microscopy. The majority of fiber concentrations were close to the detection limits, although some values were higher. In terms of fibers longer than 5 micrometers, the fibers generally associated with health risk, all concentrations were at or very close to the detection limits.

### 1.1.2 SOIL INVESTIGATION

Surface, near-surface and sub-surface soil samples were collected from on-site and off-site locations and analyzed for various chemical parameters and physical properties. Data from the analysis of 31 soil samples indicated that no thiram was present at detectable levels of 0.028 mg/kg. Bulk asbestos content was below the limit of quantification (less than 1.0 percent). Chromium levels were low, mostly less than 30 mg/kg. However, lead levels were relatively high. Some values between 1000 and 4700 mg/kg were found in areas where solid wastes have been disposed. Lead levels in off-site soil samples were very low, mostly less than 20 mg/kg. Organic contaminant levels were relatively very low.

### 1.1.3 GROUNDWATER INVESTIGATIONS

Five monitoring wells were installed on the periphery of the site. These were sampled and analyzed for asbestos and other chemical parameters. Groundwater elevations and aquifer characteristics were also measured. The groundwater elevation and temperature data indicated that the groundwater at the site ultimately moves eastward to Lake Michigan.

The soil and well boring data indicated that underneath the deposited wastes is an unconfined water table aquifer 25 to 30 feet thick which lies over a clay layer. This clay layer is reported to be over 50 feet thick and dips from west to east into Lake Michigan. The observed hydraulic conductivity of the sands in this aquifer ranged from 0.0162 cm/sec to 0.0255 cm/sec.

Groundwater sample analysis data indicated that asbestos fiber counts by phase contrast microscopy were below detection limits. Results of analysis of samples by electron microscopy have identified presence of asbestos in the range of 6 to 12 million fibers per liter. Analysis of Lake Michigan shore water samples by electron microscopy also showed similar asbestos fiber concentrations (5.5 to 19 million fibers/l). These observed concentrations are similar to those reported in the literature for tap water and commercial beverages. Traces of lead, barium, copper, arsenic, boron, iron, manganese and zinc were detected in some of the samples. All detected compounds were present at levels below the drinking water standards.

Water balance survey at the plant was conducted to determine the fate of process water treated at the site and to determine the groundwater recharge for the service water recycled from the site. The survey findings were that the seepage from the 57 acres of treatment and recycling basins is normal (about 1/4 inch per day). Most of the seepage is anticipated to serve as the recharge for the service water recycling basins, and no seepage from the site is estimated to migrate in the northerly direction away from the service water recycling basins.

## 1.2 ENDANGERMENT ASSESSMENT

An endangerment assessment is presented for lead and asbestos.

Lead was found to be present in relatively high quantities on the site, primarily concentrated on and around the solid waste disposal areas on the south side of the site. The site is primarily associated with asbestos, and chrysotile fiber concentrations, for fibers of all lengths, observed in on-site air samples were higher than those observed in off-site samples.

Major toxic effects of lead are anemia, neurological disfunction and renal impairment. Chronic exposures decrease synthesis of hemoglobin and can also result in lead encephalopathy (neurological dysfunction). Lead is a suspected human carcinogen. Lead also exhibits toxicity at low levels to aquatic organisms. Fish are affected by chronic exposures. These effects generally are less in hard waters. Leachability of lead to groundwater is very low at this site because of alkaline nature of the wastes disposed at the site. Potential of exposure to lead through fugitive dust appears to be low. However, this will be evaluated using air monitoring for lead and presented in a technical memorandum by September 15, 1985.

Major total effects associated with inhalation of asbestos fibers are asbestosis, bronchogenic cancer, pleural and peritoneal mesothelioma and thickening of the pleura. Amphibole fibers appear to be more toxic than chrysotile fibers. No carcinogenic or other effects have been demonstrated to result from ingestion of asbestos fibers in food or water supplies, and there are no known effects of ambient asbestos fibers on non-human species. For asbestos fibers longer than 5 micrometers, all observed values were at or near the detection limit.

Site access is restricted and there are no residential dwellings and groundwater drinking supplies within 0.5 mile radius of the site.

The exposure potential and intended risk to human health and environmental resources in the vicinity of the site is considered low.

### 1.3 CONCLUSIONS

The Johns-Manville, Waukegan, Illinois site has some soil contaminated with relatively high levels of lead. However, due to the alkaline nature of the wastes disposed at the site, the lead is not readily releasable to the environment.

*This hasn't been proved as yet.*

Asbestos fiber concentrations on site for fibers of all lengths are somewhat higher than off site. However, all concentrations for fibers longer than 5 microns are at or near the detection limit.

*→ Now is this possible when only fibers of  $\leq 5$  microns were measured.*

The groundwater at the site is of drinking water quality in spite of many years of waste disposal activities at the site. The groundwater appears to move ultimately towards east to Lake Michigan.

The off-site migration potential of contaminants from the site is low. The site does not threaten the existing or future uses of Lake Michigan water, groundwater, air, and other environmental resources in the vicinity or the site.

*Contradict.  
P3-7 under Hydrology*

INTRODUCTION

Kumar Malhotra and Associates, Inc. (KMA), was retained by the Johns-Manville Sales Corporation ("Johns-Manville") to perform geotechnical and hydrological investigations at the Johns-Manville Disposal Area in Waukegan, Illinois. The purpose of these soil and groundwater investigations is to identify and evaluate the nature and extent of existing site contamination. Ontario Research Foundation was retained by Johns-Manville to conduct an air sampling program in the vicinity of the site and on site.

The air, soil and groundwater investigations were conducted during the fall of 1984 in accordance with the detailed work scope outlined in the Administrative Order by Consent between USEPA and Johns-Manville signed on June 14, 1984. A copy of the consent agreement is included in Appendix I. Also, Johns-Manville conducted a plant water balance study in January 1984. Its purpose was to evaluate the fate of wastewater treated at the site using settling ponds. A report on this study was submitted to USEPA by Johns-Manville during the spring of 1984. The preliminary results of the air, soil, and groundwater evaluations and water balance study were discussed with USEPA and Illinois EPA representatives in a meeting at Waukegan, Illinois, on January 11, 1985.

This Remedial Investigation (RI) report presents details of air, soil, and groundwater investigations including procedures used and results obtained. Based on the results obtained an interpretation of the nature, distribution, quantities, and characteristics of on-site and off-site contaminants is presented. Brief descriptions of the site area, history, and environmental settings have been included to allow sufficient understanding of the interrelationships of the remedial investigations and assessment of potential or actual hazard to public health and the environment. The data presented in the RI report are necessary for preparing the required endangerment assessment and as a basis for evaluating the need and appropriateness for remedial actions at the site.

### 3.0 EXISTING DATA EVALUATION

This section summarizes available technical data and background information on the Johns-Manville site and its surrounding area, as well as the potential effects resulting from site contamination.

### 3.1 BACKGROUND SITE DATA

#### 3.1.1 SITE LOCATION

The Waukegan disposal area is located on the shorelines of Lake Michigan in the northeast corner of Waukegan City limits and immediately south of Illinois Beach State Park. The disposal area covers approximately 120 acres out of the 300 ± acres of land owned by Johns-Manville. This land lies in the southern half of Section 10, Township 45N, Range 12E, Lake County, Illinois. See Figures 3-1, 3-2, and 3-3 for vicinity map, regional location map and site location map respectively.

#### 3.1.2 SITE DESCRIPTION

The Waukegan plant site is bounded by Lake Michigan on the east, Illinois Beach State Park on the north, an old city dump site on the west, and a fossil fuel electrical power generating station on the south. The disposal area has been used for the disposal of wastes from the manufacturing of roofing materials, pipes and insulating products. The topography varies and it is assumed that the area was originally a marsh similar to the state park immediately to the north of this property. Surface runoff from the disposal area is estimated to flow to existing ponds on the site and to Lake Michigan. There is an intermittent flow creek starting at about 3000 feet north of the site and flowing northeast to the Dead River discharging into Lake Michigan. The site presently consists of solid waste disposal areas and a closed loop process water treatment system. There are currently three general solid waste disposal areas on the southeast area of the site shown in Figure 3-3. These are labelled as asbestos disposal pit, miscellaneous disposal pit and sludge disposal pit. The closed loop water treatment system consists of three separate process water discharges into a series of settling basins with the water returning to the plant via the Industrial Canal along the north side. This canal serves as a barrier between the waste disposal area and the northern property boundaries.

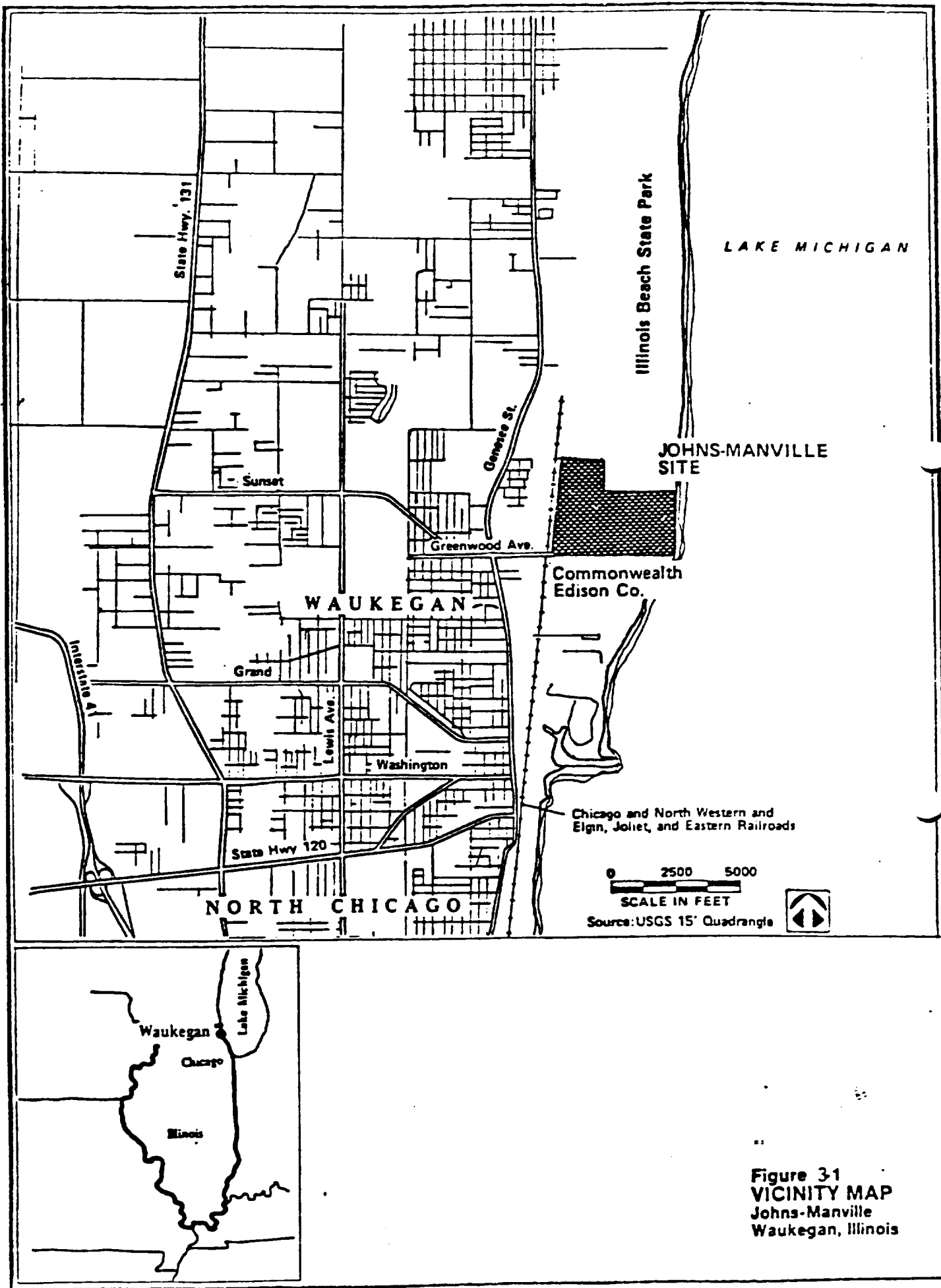


Figure 3-1  
VICINITY MAP  
Johns-Manville  
Waukegan, Illinois



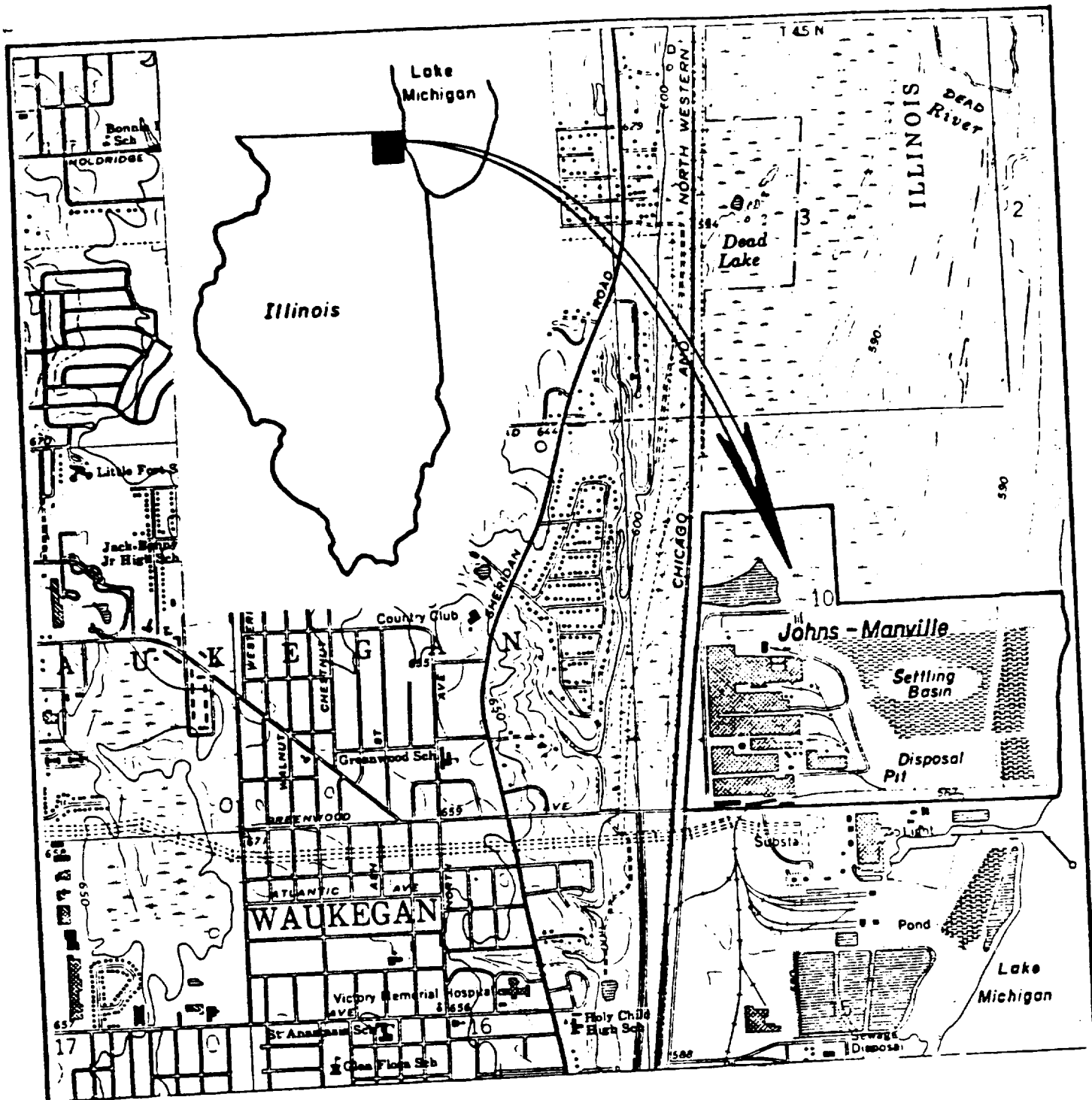


FIGURE 3-2  
REGIONAL LOCATION MAP  
JOHNS-MANVILLE DISPOSAL AREA  
WAUKEGAN, ILLINOIS

S94 - 3224

Map adapted from  
USGS Zion Quad. Map

Kumar Malhotra & Assoc, Inc - Grand Rapids, Michigan

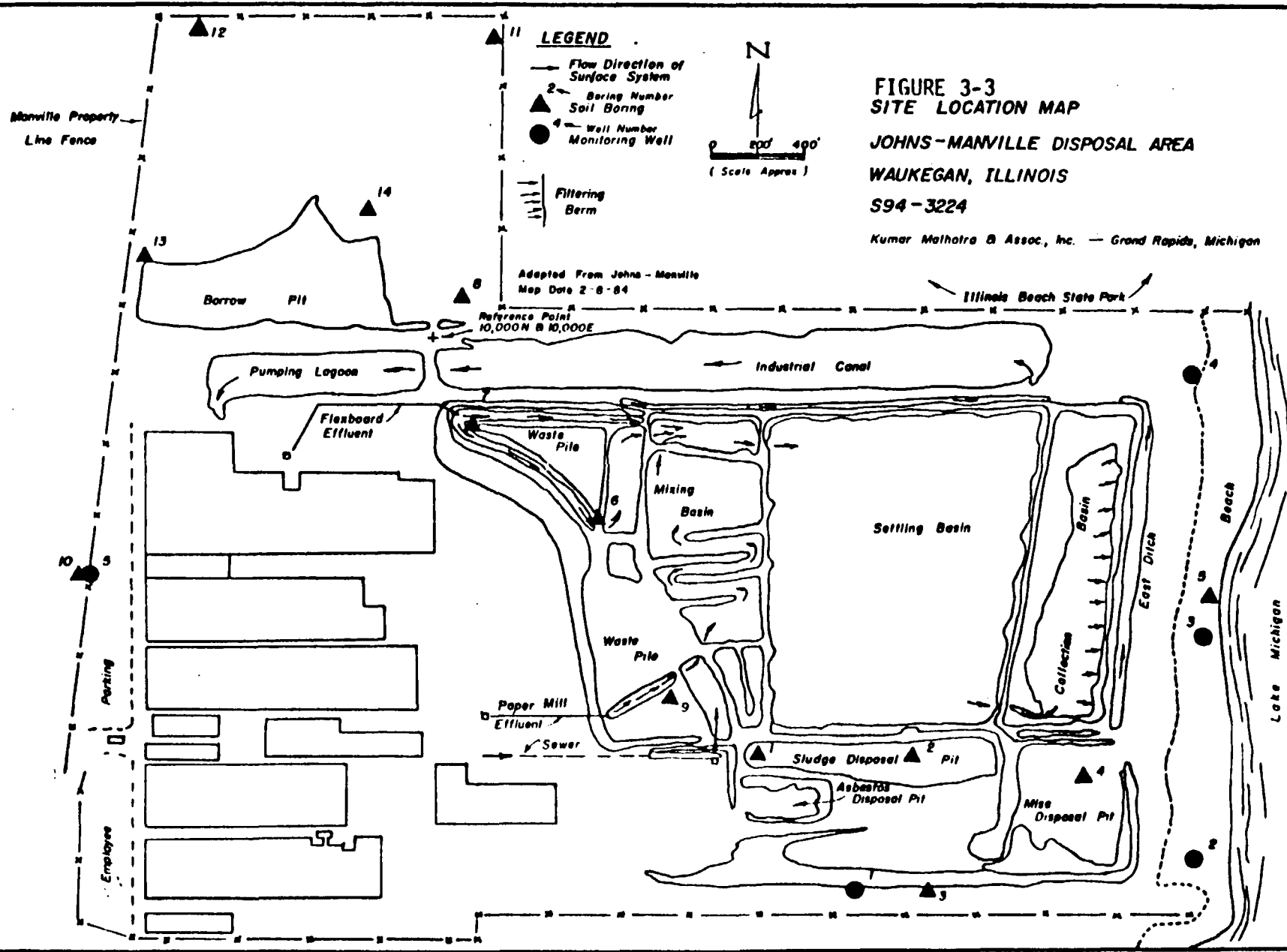


FIGURE 3-3  
SITE LOCATION MAP  
JOHNS-MANVILLE DISPOSAL AREA  
WAUKEGAN, ILLINOIS  
S94-3224

Kumar Malhotra & Assoc, Inc. — Grand Rapids, Michigan

The following observations were noted during site visits:

- 1) Site is well isolated from residential population.
- 2) No drummed material is left on-site.
- 3) Visible non-friable asbestos containing materials exist on-site.
- 4) Plant waste materials are levelled and covered routinely. Wastes disposed in the asbestos disposal pit are covered within 24 hours of dumping and others are graded and compacted at least once per week.
- 5) The site is fenced on three sides and bordered on the east side by Lake Michigan.
- 6) Recreational use of Lake Michigan is made immediately south of the site.
- 7) No visible seeps or leachates are present from side slopes or elevated wastewater treatment and solid waste disposal areas.

### 3.1.3 SITE HISTORY

The site is reported to have received asbestos containing wastes. The wastes are primarily cuttings and waste products from the manufacturing of asbestos- cement pipe and residues containing roofing and insulating materials. This site has received friable and non-friable asbestos wastes since 1922. It has also received trace quantities of waste materials containing chromic oxide, lead, thiram and xylene. The use of asbestos substitutes and changes in product lines have now eliminated the major use of asbestos fiber from the manufacturing processes as well as from the wastes disposed of at this site.

This site was included in the National Priorities List in 1982. Johns-Manville contested the basis for this listing. Nevertheless it has entered into a consent agreement with USEPA to conduct a remedial investigation and feasibility study for the site. See Appendix I. A chronological survey of the site is included in Appendix A.

## 3.2 ENVIRONMENTAL SETTING

The following sources were used in compiling information for this Section.

### (i) Personal Communications with:

Mr. William Mains, U. S. Environmental Protection Agency  
Mr. Brad Benning, Illinois State Environmental Protection Agency  
Mr. Robert Sasman, Illinois State Water Survey

Mr. Mike Coan, Mr. Ken Bartow, Lake County Health Department  
Ms. Paula Trig, City of Waukegan  
Illinois State Geological Survey, Records Division  
Mrs. Sidhu, Lake County Planning Section.  
(ii) Documents/Reports:

SUMMARY OF THE GEOLOGY OF THE CHICAGO AREA; William, H.B.,  
Circular 460, Illinois State Geological Survey, Urbana, IL.,  
1971

GEOLOGY FOR PLANNING IN LAKE COUNTY, ILLINOIS; Larsen, Jean I.,  
Circular 481, Illinois State Geological Survey, Urbana, IL.,  
1973

GLACIAL DRIFT IN ILLINOIS, THICKNESS AND CHARACTER; Piskin,  
Kemal and Bergstrom, Robert E., Circular 490, Illinois State  
Geological Survey, Urbana, IL., 1975

GUIDE TO THE GEOLOGIC MAP OF ILLINOIS; Illinois State  
Geological Survey, Educational Series 7, Urbana, IL, 1961

A HYDROLOGIC STUDY OF ILLINOIS BEACH STATE PARK, Visocky,  
Adrian, P., Illinois State Water Survey, 1977

REMEDIAL ACTION MASTER PLAN, Johns-Manville, Waukegan, Illinois  
Prepared by CH2M Hill, October, 1983.

### 3.2.1 PHYSIOGRAPHY

Lake County is in the Wheaton Morainal part of the Great Lake Section of the Central Lowland physiographic region. The landscape of Lake County has been shaped by action of water and ice. At the Johns-Manville site, the local physiographic unit is the Lake Border Morainic System.

The general topography surrounding the Johns-Manville site is level. The process buildings are on natural ground. The highest part of the disposal area is about 40 feet above natural ground. The surface topography of the waste area is irregular. In general, peripheral portions of the site slope away from the center of the site. In the vicinity of the wet basins, drainage is to the basins. Part of the south portion of the site slopes into closed depressions, such as the asbestos disposal pit, the miscellaneous disposal pit and the sludge disposal pit. The southwestern portion of the disposal area slopes generally to the west. The southeastern portion of the disposal area generally slopes to the east, towards Lake Michigan.

### 3.2.2

#### GLACIAL GEOLOGIC SETTING

The Johns-Manville facility is situated on an area of unconsolidated glacial drift. Glacial drift at the site ranges from 75 feet to 100 feet in thickness. Significant areas on and around the site are "man made" land. These areas consist primarily of sandy fill over lacustrine sands of Glacial Lake Chicago. The lacustrine sands range from 25 feet to 50 feet in thickness. The sands overlie the Wadsworth Till Member of the Lake Border Moraine System.

The till deposits range in thickness from 50 feet to 75 feet. The Wadsworth Till Member consists of silt-clay-sand matrices of low permeability. Gravel, cobbles, and boulders may be included in the till. Lenses of sandy material are occasionally found within the till.

A thin sand and gravel deposit underlies the till. This layer ranges from 15 to 20 feet in thickness and is underlain in turn by the bedrock.

A Hydrologic Study of Illinois Beach State Park by Visocky (1977) provides a good overview of the glacial geology and the hydrology of the area.

### 3.2.3

#### BEDROCK GEOLOGY

The uppermost bedrock consists of Silurian age dolomite of the Niagaran-Alexandrian Dolomite. The formation is silty at the base and may locally be cherty. The dolomite has a thickness of 300 feet and dips to the east. Pockets of oil, gas, and hydrogen sulfide of ecological origin are occasionally encountered within this formation.

A succession of shales, dolomites and sandstones complete the stratigraphic column above the PreCambrian age granite. Three of these strata are significant water producing zones. They are the Glenwood-St Peter Sandstone, the Ironton-Galeville Sandstone, and the Mt. Simon Sandstone.

### 3.2.4

#### HYDROLOGY

The Johns-Manville site is located on the Lake Michigan shore. [The lakefront area is subject to storm waves and erosion periodically.] Drainage at the Johns-Manville site is primarily collected either in catch basins at the paved areas or in the wet waste basin system and recycled. At (the southeast portion of the site, there may be surface runoff to Lake Michigan. *Don't this contradict KMA's pb transport statement?* } P. 1-4

Water supplies for the City of Waukegan are drawn from Lake Michigan from a location about one mile southeast of the site. After use, this water is returned to Lake Michigan in the form of treated effluent.

Groundwater resources are available everywhere in Lake County. The five major water-yielding units are: the glacial drift aquifers within the lacustrine sands, the shallow dolomite aquifer (Silurian), the Glenwood-St Peter Sandstone, the Ironton-Galesville Sandstone, and the Mt. Simon Sandstone. The two aquifers closest to the surface, the glacial drift and shallow dolomite aquifers, form the shallow system and are replenished or recharged by local rainfall. The remaining three deep sandstone aquifers are recharged by precipitation seeping downward through the overlying rocks on a regional scale.

In the northern portion of Lake County, the Glacial drift aquifer ranges from 15 to 50 feet in depth and is buried underneath till. Superficial aquifers within the lacustrine sands often contain sufficient ground water to supply household needs. Water within these formations generally moves laterally toward the Lake Michigan shoreline. Small artesian aquifers in the glacial tills may occasionally yield enough water for domestic supply. However, these aquifers are usually of limited aerial extent and thickness. Often they are poorly connected with the superficial water bearing formations.

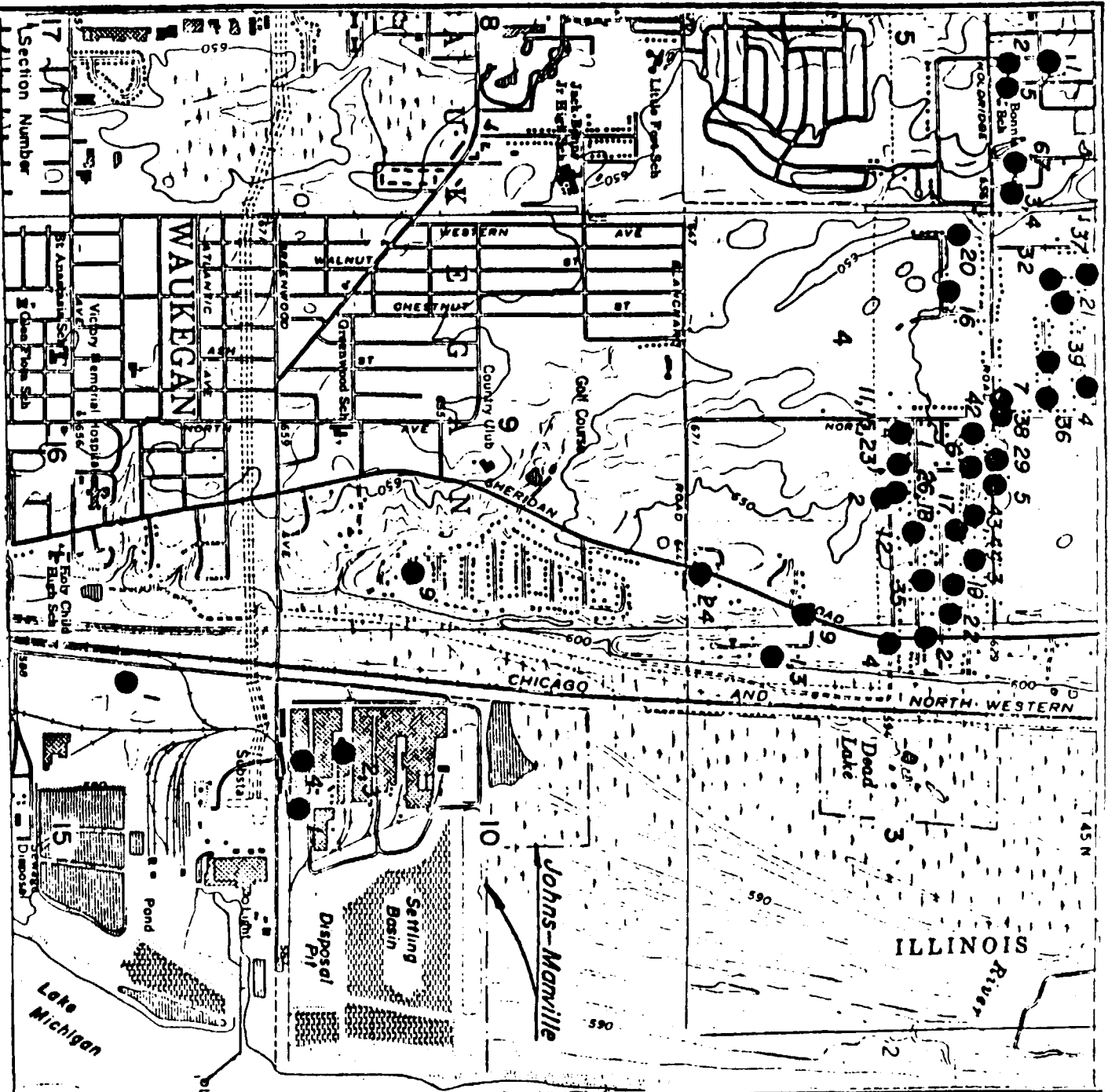
The uppermost third of the Silurian dolomite is the most productive zone within this formation. Fractures, crevices, and solution cavities all contribute to this formations porosity. Water quality may, however, be poor due to oil, gas, or hydrogen sulfide of ecological origin within the dolomite, more likely from the marshes along the Lake Michigan shore areas.

The Galesville Sandstone aquifer is the most productive of the deep sandstone aquifers. It generally produces 1,000 gallons per minute (gpm) or more. The St. Peter Sandstone produces moderate quantities of water. The Mt. Simon Sandstone aquifer has the potential to produce large quantities of water. However, it is not generally economically feasible to develop this aquifer because the Mt. Simon aquifer occurs at great depths and becomes too saline for use without treatment.

Deeper aquifers are or have been used for water supply in the past. These often contain water too highly mineralized for use without treatment. Frequently they are excessively expensive to use due to the large depths involved.

Water well drillers in Illinois must record their well records with state and local agencies. Figure 3-4 shows the locations of wells on record with any of the following agencies:

Lake County Health Department  
Illinois State Water Survey  
Illinois State Geological Survey



**LEGEND**  
 3 — Well NE Within The Section  
 ● Well Location

N  
 1"=2000'

FIGURE 3-4  
 WELL LOCATION MAP  
 JOHNS-MANVILLE DISPOSAL AREA

S94-3224

Map adapted from  
 USGS Zion Quad Map  
 1/85

Kumar Mohindra & Assoc, Inc - Grand Rapids, Michigan

Only those wells with records that could be confirmed by cross checking the locations with other sources are shown on Figure 3-4. Details of some wells in the vicinity of the site are as follows:

At the Johns-Manville site, four wells to the Silurian-age dolomite were drilled in 1920. The depth of these wells ranged from 108 to 132 feet below natural ground near the process buildings. The drift aquifer above bedrock was 3 to 18 feet in thickness. One nearby well drilled in 1919 and located in the SW 1/4 of the NW 1/4 of Section 15, uses the Silurian-age dolomite for water supply, and is 95 to 100 feet deep. One deep well, drilled in 1928 and also located in the SW 1/4 of the NW 1/4 of Section 15, uses the Mt. Simon Sandstone aquifer and is 1,670 feet deep. Another well drilled in 1977 and located in the NE 1/4 of the SW 1/4 of Section 9, uses dolomite aquifer for water supply. Records of these wells are presented in Appendix B.

The general groundwater movement at the Johns-Manville site is lateral and upward towards Lake Michigan.

### 3.2.6 WATER QUALITY

Little water quality information is available regarding any of the useable aquifers discussed above. One analysis of a shallow well and one of a deep Sandstone aquifer well located approximately one-half mile south of the Johns-Manville site is included in Appendix C. The shallow well shows fairly typical water quality with the exception of the high sodium, chloride and dissolved solids levels. The deep well water data shows that water is hard and has high mineral content.

Surface water and ground water samples were taken by Illinois State Water Survey during a study of the Illinois Beach State Park in 1975 and 1976. Some of the results are presented in Appendix C. Details of this study are summarized in the report "Hydrologic Study of Illinois Beach State Park" by Adrian P Visocky, 1977.

### 3.2.7 AIR QUALITY

Two previous air monitoring programs have been conducted at the site. On December 8, 1973, ambient air samples were collected by the Illinois Institute of Technology Research Institute (IITRI). Also airborne asbestos samples were collected by Ecology and Environment, Inc. (EEI) on April 28, 1982. However, while quantitative estimates of airborne asbestos concentration levels were produced, neither program was conducted in a manner that allows the data to be evaluated objectively with respect to

*Are any of these wells used in the area as drinking water, domestic public supply wells, etc.?*



representativeness, accuracy, and precision. (Source USEPA RAMP; Appendix B).

### 3.2.8 ECOLOGY

Johns-Manville site is located on the south side of the Illinois Beach State Park. This park is a 6.7 square mile strip of land along Lake Michigan. The portion of the park immediately north of the Johns-Manville property is composed of marsh lands with enough vegetation and shrubbery to support wild life and migratory birds. Dead River empties into Lake Michigan within the park property at a distance of about one mile from the disposal area. Areas on the south and west of the site do not provide habitat for wildlife. Surface runoff from the site is not expected to flow into the park property. Johns-Manville property on the north and northwest of the disposal area adjoining the park also contains marshy and wooded areas. These areas can provide habitat for wildlife and birds. These areas are about 2000 feet or more north of the active waste disposal pits. Wildlife may include deer, squirrel, ruffed grouse, ringneck pheasant, cottontail rabbit and small rodents. In addition, the industrial canal on the north side of the site and Lake Michigan on the east side can attract wild ducks and migratory birds.

*Why? ←* *What about migration potential?*

Lake Michigan on the east side of the site and cooling water ponds of Commonwealth Edison Company on the southeast side of the site are recreational fishing bodies of water.

No adverse impacts of Johns-Manville waste disposal activities have been reported on the vegetation, birds and wild life in the vicinity of the site.

### 3.2.9 SOCIOECONOMICS

Johns-Manville disposal area is located in the industrial belt along the eastern edge of the City of Waukegan. Waukegan is the largest city in Lake County. Waukegan population has grown from 65,134 in 1970 to 67,650 in 1980. During the same period Lake County grew from 382,638 to 440,372. The major cities experiencing increased rate of growth in the Lake County are North Chicago, Gurnee, Libertyville, Mundelein and Zion.

The City of Waukegan has many manufacturing and processing industries including a Commonwealth Edison fossil fuel power plant. Great America Amusement Park is located approximately seven miles southwest of the site. This park is a major attraction during the summer and early fall. There is no residential dwelling within 1.0 km radius of the site. There are approximately 200 homes within 1.0 mile radius of the western edge of the site. Within 0.5 mile radius of the site there are about 1800 workers during

the day shifts and about 450 workers during the night shift. These are all adult workers. Within 1.0 miles radius of the site the number of persons estimated to be present during the day shifts is 4,750 and night shift is 2,225. Approximately 20 percent of these are area residents and 80 percent industrial and commercial workers. Within 1.5 mile radius of the site the day shift population is estimated to be 12,600 and night shift population to be 7,450. Approximately 40 percent of these are estimated to be area residents and remaining industrial and commercial workers or non-area residents.

Most of the residential homes are located northwest of the site and are inhabited by moderate income families. The residential property values as well as renter occupancy and rental values in the vicinity of the site have been keeping pace with inflation and values in other residential areas of the city. There has been no documented adverse impact on the tourism and recreational activity in the vicinity of the site or in Lake County.

### 3.3 PLANT DESCRIPTION

The Johns-Manville plant produces and has produced a wide range of building materials composed of a variety of substances. During 1922 to 1923, it made low-temperature pipe coverings, packing, insulating cements, roofing products, asbestos and rag felt papers, and magnesia and asbestos shingles. Since 1923, the plant has also produced asphalt floor tile, roofing felts, acoustic tile, asbestos-cement pipe, cut gaskets, siding shingles, flexboard, wallboard, clapboard, rock wool, and glass fiber shingles. Major products produced now include mineral panels (known as flexboard), asphalt roofing products, calcium silicate insulation (known as T-12), refractory fiber and sealing components.

The major raw materials used were Portland cement, asphalt, paper and asbestos. The use of asbestos substitutes and changes in product lines have now eliminated major use of asbestos fiber from the manufacturing processes as well as from the wastes disposed of at this site.

#### 3.3.1 WASTE TYPES AND THEIR HANDLING

There are two general types of wastes disposed of at this facility. These are:

- i) Solid waste in the form of cutting, residues and off-specification products.
- ii) Process waste water.

Almost all of the wastes generated in these two categories have been treated/disposed on site since 1922. Currently three areas receive the solid waste or residues. These are

shown in Figure 3-3 as sludge disposal pit, asbestos disposal pit and miscellaneous disposal pit. The process waste water is pumped to a series of unlined settling basins (See Figure 3-3) where it is treated and recycled via an industrial canal and pumping lagoon. There is no direct discharge to any surface water. The asbestos disposal pit received all friable asbestos waste and is managed in accordance with the requirements of National Emission Standards for Hazardous Air Pollutants (NESHAP). The miscellaneous disposal pit receives loose and baled scrap products. The solid waste is dumped, covered and graded. The sludge disposal pit is a depression where dredge spoils from the process wastewater settling basins are discharged periodically.

### 3.3.2 WASTE MATERIALS CHARACTERIZATION

The following information has been obtained from RAMP prepared by CH2M HILL:

"Hazardous materials known to be disposed of at the Johns-Manville site consist of the following: asbestos, chrome, lead, xylene, and thiram. In April 1973, a survey was conducted of the solid waste generated at the Johns-Manville Site. An estimate of the solid wastes containing asbestos generated before April 1973 and the solid wastes containing asbestos disposed of as of April 1973 are presented in Tables D-1 and D-2 respectively included in Appendix D. An estimate of the hazardous wastes generated and disposed of onsite before August 18, 1980, is presented in Table D-3. An estimate of the hazardous wastes disposed of in an incorporated form (in trimmings from finished products, or in reject products before August 18, 1980, is included in Table D-4. Tables D-3 and D-4 are presented in Appendix D. In addition, about 17,410 pounds of waste asbestos per month was contained in slurry that was going into the wet waste basin system.

Since December 1980, monthly estimates have been made of the hazardous wastes disposed of in the onsite area. These estimates were not derived from any actual testing and should be considered gross estimates. The average monthly estimates between December 1980 and February 1983 are as follows:

Raw asbestos - 72 pounds for 27 months

Chrome - 21 pounds for 10 months

Lead - 1 pound for 18 months

Xylene - 0 pound 27 months

Thiram - 41 pounds for 17 months

The chrome referred to in the above estimate was the chrome contained in chromic oxide and was used to produce chroma fiber. Chrome is not listed as a hazardous waste, but is a waste that exhibits the characteristics of EP toxicity. If the chrome exhibits EP toxicity it is a hazardous waste for the purposes of the Resource Conservation and Recovery Act (RCRA) regulations. The only waste chromic oxide generated is that which may cling to the shipping containers and that which might be produced in the mixing area and collected in the dust house. The waste chromic oxide that is left in empty containers is not subject to RCRA regulation. The waste chromic oxide in the dust house would occur in small amounts because it is generally used only 2 months out of the year.

The lead that is referred to in the above estimate was used in the form of lead oxide to produce sheeting materials. The waste materials containing encapsulated lead oxide were hauled to the waste disposal pits and periodically levelled, compacted and covered. Lead is no longer used in the manufacturing process and no longer generated as a waste.

The thiram referred to in the above estimate was that used in sheet manufacture and that which may cling to shipping containers. The thiram in the manufacturing process wastes is not considered to be a hazardous waste regulated under RCRA as defined by 40 CFR 261.33 (f). The thiram that is left in empty containers as defined by 40 CFR 261.7 (b) is not subject to RCRA regulations".

Thus the only hazardous component that is being disposed of at this site now is small amounts of friable asbestos (e.g. baghouse dust, empty or broken raw material bags, and cuttings) which is regulated and managed under 40 CFR Part 61. These and waste materials containing small amounts of encapsulated asbestos fibers are generated during manufacturing of some of the mineral panels and sheet goods.

### 3.4 REGULATIONS

Asbestos is a hazardous air pollutant regulated under the Clean Air Act by National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 CFR 61M). The NESHAP requirements for asbestos waste disposal sites (40 CFR 61.156) include the following:

- o "There shall be not visible emissions to the outside air from any active waste disposal site where asbestos-containing waste material has been deposited....
- o Warning signs shall be displayed at all entrances, and along the property line of the site or along the perimeter of the sections of the site where asbestos-containing waste material is deposited....

- o The perimeter of the disposal site shall be fenced in order to adequately deter access to the general public....
- o Warning signs and fencing are not required where the requirements of (the following)\* paragraph... are met, or where a natural barrier adequately deters access to the general public....
- o Rather than meet (the first)\* paragraph of this section, an owner or operator may elect to meet the requirements of (one of the following)\* paragraph (s)....
- o At the end of each operating day, or at least once every 24-hour period while the site is in continuous operation, the asbestos-containing waste material which was deposited at the site during the operating day or previous 24-hour period shall be covered with at least 15 centimeters (6 inches) of compacted non-asbestos containing material.
- o At the end of each operating day, or at least once every 24-hour period while the disposal site is in continuous operation, the asbestos containing waste material which was deposited at the site during the operating day or previous 24-hour period shall be covered with a resinous or petroleum based dust suppression agent which effectively binds dust and controls wind erosion....."

\* Words in parentheses have been added for regulatory simplification

Chromium and lead, as defined by 40 CFR 261.24, are regulated under RCRA if they exhibit the characteristics of EP toxicity. To exhibit the characteristics of EP toxicity, the maximum concentration of contaminants for both chromium and lead is 5.0 milligrams per liter in the leachate extraction.

Xylene, as defined by 40 CFR 261.31, is regulated under RCRA as a hazardous waste from nonspecific sources. Xylene is a spent nonhalogenated solvent and exhibits characteristics of ignitability.

Thiram, as defined by 40 CFR 261.33, is regulated under RCRA as a toxic waste.

The USEPA ambient water quality criteria for protection of human health from ingestion of water are presented in Table 3-1.

### 3.5 MANAGEMENT PRACTICES

Johns-Manville has a senior level employee at the plant, namely the Plant Manager, who is responsible for the overall operation of the plant. In particular, he has a trained staff who are responsible for the operation of the waste handling and disposal activities. A permit was issued by the State of Illinois for process waste water

Table 3-1

USEPA AMBIENT WATER QUALITY CRITERIA  
JOHNS-MANVILLE  
WAUKEGAN, ILLINOIS

Substance	Toxicity (ppb)	Carcinogenicity <sup>a</sup> (f/l)
Asbestos	NCA	300,000
Chromium (total hexavalent)	50	NCA
Chromium (total trivalent)	170,000	NCA
Lead	50	NCA
Thiram	NCA	NCA
Xylene	NCA	NCA

ppb = Parts per billion.

f/l = Fibers per liter.

NCA = No criteria available.

<sup>a</sup> Carcinogenicity protection of human health from ingestion of water at the  $10^{-5}$  risk level.

Source: USEPA 1980. (RAMP)

management using a closed-loop recycle system in 1973. There have been no documented violations of this permit since this was issued. The requirements of Clean Air Act for asbestos waste disposal sites and of OSHA for exposure are being met. All personnel handling friable asbestos containing waste use proper protective clothing and breathing apparatus. They are regularly briefed on changes in waste components so that adequate and timely waste management is provided. The friable asbestos wastes are covered with 6" clean soil cover within 24 hours of dumping. Other solid wastes are graded and compacted at least once per week. Bermed disposal pits are used to minimize wind blowing of paper and other light materials. Cyclone fencing is used to control public access. Dust from the unpaved roads is suppressed by sprinkling water at least once per week during the summer months.

## 4.0

### REMEDIAL INVESTIGATIONS

This section summarizes all activities carried out to obtain the necessary site topographic and air, soil, and groundwater contamination data for evaluating and selecting remedial measures during a feasibility study. These activities include the following:

- 4.1 Work Plan Preparation
- 4.2 Site Reconnaissance
- 4.3 Soil Sampling and analysis
- 4.4 Monitoring Well Installation and Groundwater Movement
- 4.5 Ground water sampling and analysis
- 4.6 Water Balance Studies
- 4.7 Air Sampling and analysis

## 4.1

### WORK PLAN PREPARATION

On April 19, 1984 KMA representatives met with Johns-Manville representatives to establish lines of communication, conduct a joint site visit, and discuss the objectives of the project. Another meeting was held on the project at Johns-Manville Service Corporation office on May 18, 1984. Following these meetings KMA compiled and evaluated available site information, including photogrammetric, geologic, and hydrologic data; site historical and operational data; and results of previous site investigations.

A draft work plan was prepared and submitted to USEPA and Illinois EPA in July 1984. This work plan included a draft Quality Assurance/Quality Control (QA/QC) plan. This QA/QC plan was designed to establish procedures governing reliability of field and laboratory activities. The items presented as part of the QA/QC plan included the following:

- o Project organization, authority, and responsibilities.
- o Equipment and instrument calibration and maintenance.
- o Site exploration and sampling activities, including record requirements and sample acquisition and handling.
- o Laboratory methods and analysis quality control.
- o Compliance audits and records administration.

A health and safety plan was also included in the work plan. This plan provided the worker health and safety protection measures enforced during the site work along with a site-specific protocol for implementing these protective measures. Level C protection was provided for site visits and a decontamination trailer was provided during soil and groundwater sampling.



## 4.2

### SITE RECONNAISSANCE

#### 4.2.1 TOPOGRAPHIC MAP

A detailed topographic map of the site (1-foot contour interval) with grid points and proposed location of soil borings and monitoring wells was provided by Johns-Manville. KMA used services of the Blackledge Group of Wauconda, Illinois to establish the elevations and locations of borings and monitoring wells after the soil and groundwater sampling activities were completed.

#### 4.2 2 DOCUMENTATION OF ENVIRONMENTAL CONDITIONS

The documentation of environmental conditions at the site is a summation of field observations made while traversing the site and adjacent area during soil and groundwater sampling activities. Salient items identified for documentation are:

- Land usage
- Distribution of wastes
- Exposures of subsurface materials
- Vegetation
- Seepage zones.

##### Land Usage

The site has been in use for disposal of large quantities of waste asbestos-cement pipes, asphalt roof shingles and other solid residues from the plant. Many of these materials have been used for constructing dikes for process water settling ponds and are still exposed. At the onset of KMA field operations (September, 1984) the site was in use for the disposal of solid waste from the plant. The waste was brought from the plant to disposal pits shown in Figure 3-3 regularly and covered and graded. Settling ponds were used for treating and recycling process waste water.

The adjacent properties to the site were open lands with very little human activity, except on the south side where Commonwealth Edison Company employees and private citizens were observed.

##### Distribution of Wastes

The major area of waste deposits coincides with the previously identified areas shown in Figure 3-3 as waste disposal pits. In addition, the dikes and waste piles were found to be composed of manufacturing waste materials. These waste materials are primarily cuttings and waste products from the manufacturing of roofing shingles and asbestos-cement pipes and sheets. The asbestos in these waste materials is in the encapsulated or bound form.

### Exposures of Subsurface Materials

Exposure of buried waste was observed at settling pond dikes. Most of these wastes were composed of asphalt shingles, asbestos-cement crushed pipes and bundles of insulating sheets. No drums were observed.

### Vegetation

There was very little vegetation on the disposal site. Defoliant has been used to control vegetation around and on the site. Vegetation observed was not stressed. Abundant vegetation existed to the north and east of the site. Vegetation along the south edge of disposal site was normal.

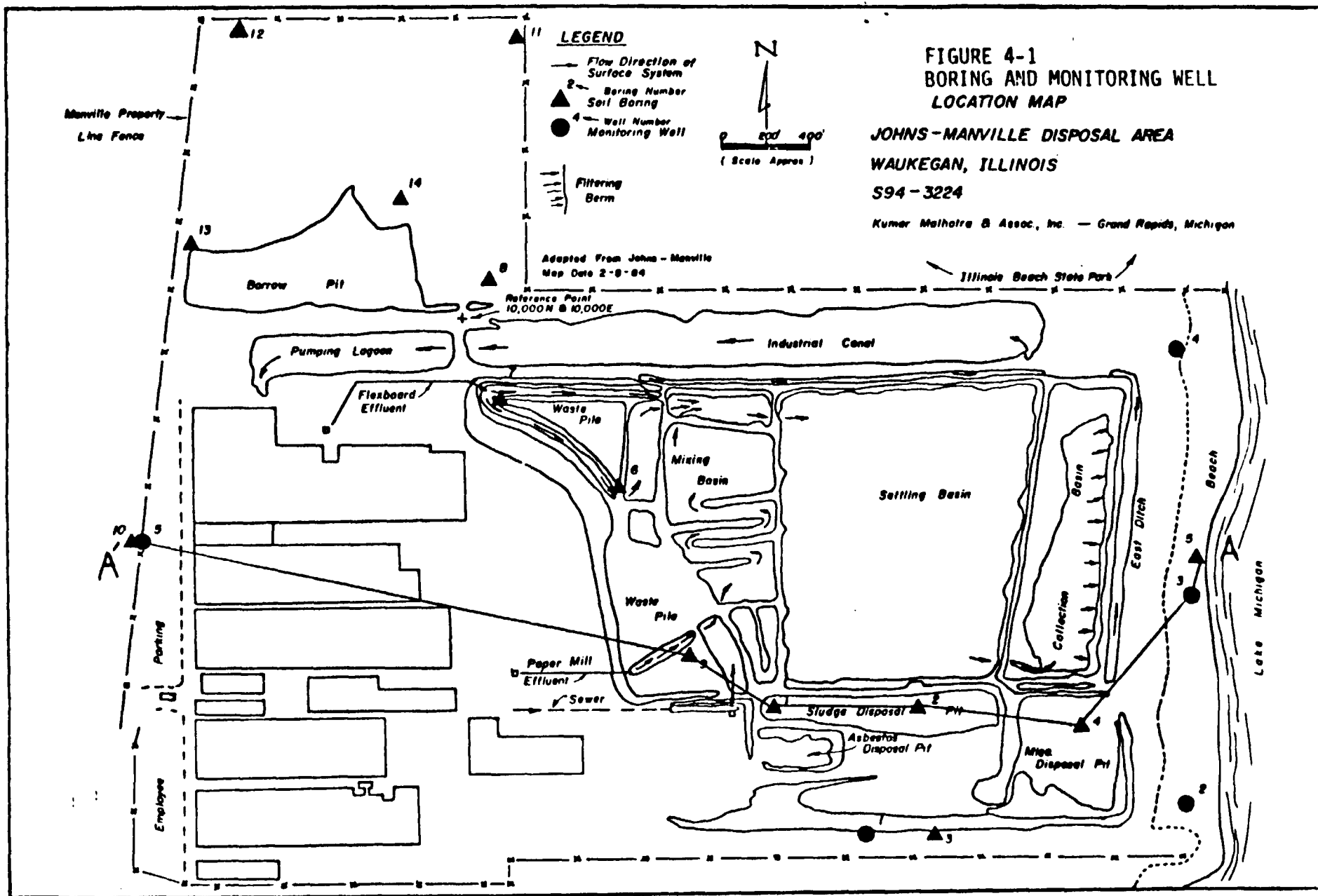
### Seepage Zones

No seepage zones or seeps were observed at the site in spite of the elevated location of the waste disposal site. Near-surface ground water was evidenced by the presence of phreatophytic vegetation (cattails, smartweed) in the low areas along the eastern side of the site between the gravel access road and lake shore line.

## 4.3

### SOIL SAMPLING AND ANALYSIS

Soil sampling included surface, near surface and sub-surface soil sampling. The soil sampling was done to obtain information pertaining to surface and sub-surface conditions at the site. Fourteen borings (boreholes) were made at on-site and off-site locations in September, 1984. These locations are shown on Figure 4-1. The locations of Borings 1 through 10 were selected to provide data on the nature and extent of waste materials and contaminants present in the wastes disposed at the site. Borings 11 through 14 were selected to evaluate the soil properties in the area north of the site for possible use as cover materials during waste disposal activities.



#### 4.3.1

#### SAMPLING METHODOLOGY

Since the perimeter borings were not to exceed 30 feet below the maximum depth of waste deposition, the maximum depth of penetration used was 40 feet. The on-site borings were to penetrate only to the base of the waste materials and sufficiently beyond to determine that the natural soils had been reached. Boring locations were marked and pegged during reconnaissance survey of the site. Borings 1 through 13 were drilled with a Central Mine Equipment Model 45 drill rig using hollow stem augers. The drill rig was decontaminated between each boring with a soap wash and a tapwater rinse. Boring 14 was drilled using a hand auger.

Samples were obtained from Borings 1 through 13 using a two-inch diameter by 18-inch long split spoon sampler and the Standard Penetration Test procedure (ASTM D-1586). This procedure consists of driving the split spoon sampler into the soils with a 140 pound hammer dropped 30 inches. The number of blows required to drive the sampler each six inches was recorded as a measure of the soil density. The entire sampler was decontaminated between each sample with an inorganic soap water rinse, followed by a tapwater rinse, a de-ionized water rinse, an acetone rinse and finally, a hexane rinse. Samples were obtained from below the water table in the perimeter borings by collecting drill cuttings at the surface. Clay materials encountered in these borings were sampled using the split spoon method. The boreholes were plugged upon completion with a bentonite-neat cement grout.

Composite surface (0.0 - 0.5 foot) and near-surface (1.0 - 1.5 foot) samples were taken at each location. Four split spoon samples were taken in a 1 foot radius around the borehole site. These were composited to form the surface and near surface samples. A fifth split spoon sample at the borehole location provided surface and near-surface permeability sample.

Sub-surface samples were taken at 2.5 foot intervals from on-site borings and 5 foot intervals from perimeter borings. The samples were logged immediately in the field and a detailed record of the soils penetrated was prepared. Copies of these records and boring locations coordinates may be found in Appendix E. Each boring record includes the following additional information:

- o Detailed heading information (including project number, boring number, location, personnel and dates).
- o Depths of tests and samples.
- o Depths of strata changes.

The entire sample was preserved for analysis. One sample liner was jarred in an 8-ounce glass jar for permeability analysis, another 8-ounces of soil was retained in similar fashion for engineering properties analyses. The remaining soil was placed in a 500 ml glass jar with a Teflon-lined lid for chemical analyses. All sample containers were immediately labeled with the sample numbering system described in the site work plan. This numbering system designated boring location, sequential sampling number and depth identifier number. Sample depths and boring numbers were added to the label information as a cross check for the laboratory to assure sample security. A total of 105 soil samples were collected. The samples were stored at 4 degrees Centigrade until the time of analysis.

Health and safety protection measures were enforced during the site work. Personal air monitoring samplers were used to monitor the asbestos levels during field activities. The exposure levels found did not even necessitate the use of respirators. However, respirators were used as outlined in the health and safety plan included in the work plan.

#### 4.3.2 SOIL DESCRIPTION

The unconsolidated deposits consist of a lacustrine beach sand overlying a lacustrine sandy clay. The sand varies in thickness from 25 feet to 39 feet. The beach sand is occasionally overlain by dune sand which is merely re-worked beach sand. The clay surface appears to be relatively flat across the site, rising gently to the west and north. This sandy clay is gray in color and very stiff. Considerable difficulty was experienced in completing Boring 8 where 7 feet of clay was penetrated before the boring was terminated in clay. Figure 4-2 shows a geological cross section constructed using the boring records. The location of the cross section is shown in Figure 4-1. The total thickness of the clay is unknown as none of the borings completely penetrated the formation.

#### 4.3.3 SOIL ANALYSIS AND RESULTS

Thirty-one (31) soil samples were selected for analysis for various chemical constituents and all but blanks and replicates were analyzed for engineering properties. Three (3) of these were field blanks (diatomaceous earth handled in the field), ten (10) were surface and near surface soil samples, one (1) near surface soil replicate (duplicate collected in the field) and the remaining samples represented soil at different depths at different locations. The soil samples from different depths also contained one replicate soil sample from boring B-7. Table 4-1 summarizes the soil sample information on these 31 selected samples.

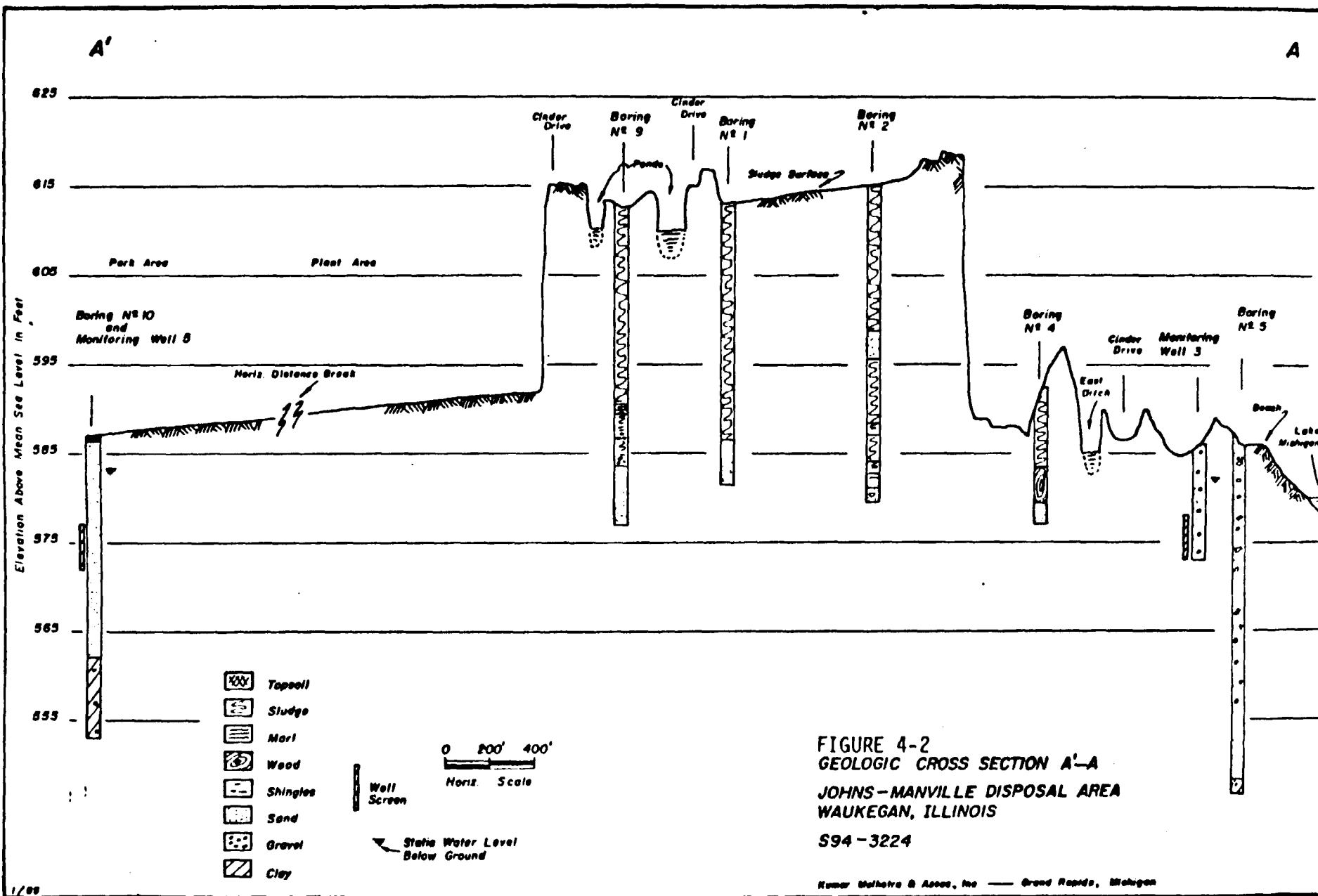


TABLE 4-1  
SUMMARY OF SOIL SAMPLES  
SELECTED FOR CHEMICAL AND PHYSICAL ANALYSIS

<u>Field Sample Number</u>	<u>Sample Depth In Feet</u>	<u>Chemical Laboratory Number</u>
JMW-SS-1-2-2	Near Surface (1.0-1.5)	4090-501
JMW-SS-1-7-6	14.0 - 14.5	4090-502
JMW-SS-1-16-6	31.5 - 33.0	4090-503
JMW-SS-2-1-1	Surface (0-0.5)	4090-504
JMW-SS-2-11-6	21.5 - 23.0	4090-505
JMW-SS-2-16-6	34 - 35.5	4090-506
JMW-SS-3-1-1	Surface (0-0.5)	4090-698
JMW-SS-3-2-2	Near Surface (1.0-1.5)	4090-699
JMW-SS-3-6-6	39.5 - 40	4090-700
JMW-SS-4-0-FB *	Field Blank	4090-507
JMW-SS-4-2-2	Near Surface (1.0-1.5)	4090-508
JMW-SS-4-5-5	6.5 - 8.0	4090-509
JMW-SS-4-8-6	14 - 15.5	4090-510
JMW-SS-5-4-6	Spun Augers and Sample From 20 Feet	4090-701
JMW-SS-6-1-1	Surface (0-0.5)	4090-511
JMW-SS-6-2-2	Near Surface (1.0-1.5)	4090-512
JMW-SS 6-7-6	11.5 - 13.0	4090-513
JMW-SS-6-12-6	24 - 25.5	4090-514
JMW-SS-7-0-FB *	Field Blank	4090-515
JMW-SS-7-2-2	Near Surface	4090-516
JMW-SS-7-2-2 *(Dup)	Near Surface	4090-517
JMW-SS-7-9-6	16.5 - 18.0	4090-518

TABLE 4-1 (continued)

SUMMARY OF SOIL SAMPLES  
SELECTED FOR CHEMICAL AND PHYSICAL ANALYSIS

<u>Field Sample Number</u>	<u>Sample Depth In Feet</u>	<u>Chemical Laboratory Number</u>
JMW-SS-7-9-6 (Dup)*	16.5 - 18.0	4090-519
JMW-SS-7-14-6	29 - 30.5	4090-520
JMW-SS-8-3-6	20 Feet	4090-702
JMW-SS-9-2-2	Near Surface (1.0-1.5)	4090-521
JMW-SS-9-6-6	9 - 10.5	4090-522
JMW-SS-9-14-6	29 - 30.5	4090-523
JMW-SS-10-2-2	Near Surface (1.0-1.5)	4090-703
JMW-SS-10-4-6	At 20 Feet	4090-704
JMW-SS-10-0-FB*	Field Blank	4090-705

\*These samples were not analyzed for physical properties



All asbestos, organic and inorganic analyses of soil samples were performed by Canton Analytical Laboratory of Ypsilanti, Michigan.

A copy of the chemical test results is presented in Appendix F. A summary of the results is presented in Table 4-2, especially of parameters which were observed in levels higher than their detectable levels.

Asbestos in the soil was determined by using USEPA method. "Interim method for the determination of asbestos in bulk insulation samples". This method specifies the use of polarized light microscopy and is presented in Appendix G.

Details of the analytical and the quality control procedures normally used by this laboratory were furnished to USEPA prior to the approval of the site work plan. Specific quality control data collected during analytical work for this site is presented in Appendix G.

All tests for engineering properties were performed by KMA. The observed values of the engineering properties are summarized in Table 4-3. These include, as was appropriate for the individual soil, Moisture Content, Specific Gravity, Grain Size (either Sieve or Hydrometer), Permeability (either Constant Head or Falling Head) and Atterberg Limits.

TABLE 4.2 SUMMARY OF RESULTS OF CHEMICAL ANALYSIS

BORING NUMBER	B-1			B-2			B-3			B-4			B-5	
Boring Depth in Feet	Near Surface	14- 15.5	31.5 33.0	Surface	21.5- 23.0	34- 35.5	Surface	Near Surface	39.5- 40	Field Blank	Near Surface	6.5- 8.0	14- 15.5	At 20
<u>Chemical Parameter (mg/kg)</u>														
Chromium, Total	16	29	9	81	42	6.6	23	12	6.1	3.8	4.4	25	5.8	1.3
Lead, Total	86	3700	630	1100	2600	190	4700	1300	13	2.4	22	1400	140	8.2
Asbestos %	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	0	< 1	< 1	< 1	< 1
Toluene (U220)	< .02	.31	0.14	-	0.51	-	-	-	-	-	0.31	-	0.62	-
Ethyl Benzene	< .02	-	-	-	.08	-	-	-	-	-	-	-	1.4	-
Di-N-Butylphthalate	< .028	0.31	0.74	-	1.2	0.28	-	-	-	0.53	0.31	0.14	0.26	-
1,2-Dichlorobenzene (U070)	0.12	0.27	-	0.58	0.78	-	<.028	-	-	-	-	-	0.20	-
1,3-Dichlorobenzene (U071)	< .028	-	-	0.077	0.061	-	-	-	-	-	-	-	-	-
Bis(2-Ethylhexyl) Phthalate (U028)	3.6	2.5	3.3	4.6	14	5.1	-	-	-	24	8.9	3.5	4.2	-
Di-N-Octyl Phthalate (U107)	< .028	0.55	0.49	-	1.5	3.3	-	-	0.064	9	1.7	1.0	0.52	-
Fluorene	< .028	0.051	-	-	0.18	-	-	-	-	-	.077	-	0.43	-
Fluoranthene	0.12	0.053	0.035	0.085	0.33	0.20	0.088	<.028	-	-	.093	-	0.34	-
Pyrene	0.13	0.089	0.043	0.098	0.30	0.19	0.092	0.16	-	-	-	.046	0.33	-
Phenanthrene	0.046	0.16	<.055	0.19	0.56	0.06	0.16	0.10	-	-	0.15	0.062	0.57	-
Anthracene	< 0.028	0.037	-	-	0.15	<0.028	0.040	0.084	-	-	-	-	.092	0.032
Benzo (A) Anthracene	< 0.028	-	-	-	-	0.20	0.045	0.074	-	-	-	-	-	-
Naphthalene (U165)	0.054	0.78	0.089	0.050	1.8	<.028	0.095	0.057	-	-	0.95	0.097	2.1	-
p-Chloro-m-Cresol (U039)	0.42	1.0	<0.02	-	0.47	-	-	-	-	-	-	-	-	-
Pentachlorophenol (U242)	< 0.3	-	-	-	-	-	6.5	-	-	-	-	-	-	12
2,4,6 Trichloro Phenol (U231)	< 0.03	-	-	-	0.45	-	-	-	-	-	-	-	-	-
PCB 1254	0.2	0.2	<0.1	0.3	0.2	-	0.2	-	-	-	-	-	-	-
Thiram	< 0.028	-	-	-	-	-	-	-	-	-	-	-	-	-

- Non Detectable

TABLE 4-4  
MONITORING WELL WATER LEVEL DATA

Monitoring Well #	Water Level Below Top Of Casing ( ft.)	Top Of Casing Elev. (USGS)	Static Water Level ( ft. above mean sea level)
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SEPT. 19, 1984

1	6.35	591.16	584.81
2	5.66	587.88	582.22
3	6.28	588.92	582.64
4	4.58	587.20	582.62
5	4.71	588.00	583.29

SEPT. 25, 1984

1	5.97	591.16	585.19
2	5.20	587.88	582.68
3	5.83	588.92	583.09
4	3.90	587.20	583.30
5	3.59	588.00	584.41

SEPT. 27, 1984

1	6.02	591.16	585.14
2	5.19	587.88	582.69
3	5.86	588.92	583.06
4	4.15	587.20	583.05
5	4.48	588.00	583.52

#### 4.4.3

#### SITE HYDROLOGY

The surficial sand layer at this site acts as an unconfined water table aquifer. Figure 4-2 shows a geological cross section constructed using the well and boring records from the September, 1984 field investigation. The lower boundary of the aquifer is the clay layer encountered at about 25 to 39 feet of depth. The total saturated thickness ranges from 22 to 37 feet across the site. The water table was encountered at 1 to 3 feet below the land surface.

The analysis of aquifer properties indicated that the sand is highly permeable. The hydraulic conductivity of the sand ranged from 0.0162 cm/sec to 0.0255 cm/sec. This is comparable with the laboratory permeability analyses of sand samples from the soil borings which ranged from 0.0017 cm/sec to 0.031 cm/sec. The ratio of the field hydraulic conductivity to laboratory hydraulic conductivity is about 10 to 1. Horizontal hydraulic conductivity is typically 2 to 10 times (or more) greater than vertical hydraulic conductivity due to the micro-layering of the sediments during deposition. The slug testing procedure measures horizontal hydraulic conductivity. The laboratory hydraulic conductivity testing measures vertical hydraulic conductivity as the samples are obtained through sampling instruments driven vertically into the soil. Thus, the micro-layering in the sediments is perpendicular to the direction of water flow in the laboratory testing equipment.

Transmissivities for the aquifer at the individual well locations are summarized and presented in Appendix H. These transmissivities are approximations based upon the estimated aquifer thickness and the calculated hydraulic conductivities at the individual well locations.

Figures 4-3, 4-4, and 4-5 show the direction of ground water movement beneath the site observed on September 19, 25, and 27, 1984 respectively. These maps show the ground water moving generally northward and then eastward. The ground water gradient on all three occasions averaged 1 foot per 1000 feet or 0.001. The gradient was somewhat higher near Lake Michigan. Note that the effects of seepage from the wastewater settling basins on groundwater levels are not monitored by these wells. The seepage from the settling basins can create a mound on the water table surface and affect ground water movement. Additional groundwater elevation data will be necessary if further definition of groundwater flow is required.

Temperatures of the groundwater were measured on September 26, 1984. This information is shown on Figure 4-6.

Soil analysis data indicated that no thiram was present at detectable levels of 0.028 mg/kg. Bulk asbestos content was less than 1.0 percent. This means that less than 3 point counts out of 400 points superimposed on either asbestos or nonasbestos matrix material were asbestos fiber, when observed under a polarized light microscope at 100 x magnification according to the point count procedure in Vol. II, Appendix G, pages G-4. Chromium levels in the soils were relatively low. The highest value observed was 81 mg/kg. Low levels of coal-tar derivatives such as anthracene, Pyrene, Phenanthrene, Napthalene etc. were present in some of the soil samples. Asphalt shingles and related waste products appear to be the source of these compounds. Some Pentachlorophenol or Trichloro Phenol (herbicide/defoliant) was present in areas where herbicide defoliant had been used in the recent past to control nuisance from uncontrolled growth of vegetation. Low levels of PCB 1254 in surface samples were observed. Lead levels were relatively high. These are more likely from the waste products when lead oxide was used in manufacturing certain products. Phthalates were observed in field blank and other samples. These compounds are generally present if plastic materials come in contact with samples.

Since a plastic container was used to store bulk soil used for field blank samples, additional samples of soil from the same source which had not come in contact with a plastic material were analyzed to evaluate the possible source of phthalates in the field blank samples. The results obtained are presented in Appendix F. These show that the source of Phthalates in the field blank was indeed the plastic container, and the soils showing presence of Phthalates must have come in contact with some plastic materials during waste handling or disposal at the site.

Engineering properties data indicated that the sludge sampled from the waste sludge pit (boring 1 & 2) and from other locations was generally silty with permeability in the range of  $6.9 \times 10^{-5}$  to  $4.41 \times 10^{-6}$  cm/sec. Material deposited around boring 3 was mostly sand and cinders. The waste materials sampled in the vicinity of the miscellaneous waste disposal pit (boring 4) and at borings 6, 7 and 9 were silty white and gray sludges mixed with other waste materials. Mostly, fine sands with permeability in the range of  $3.1 \times 10^{-2}$  to  $1.7 \times 10^{-3}$  cm/sec were encountered at borings 5, 8 and 10 and underneath deposited waste materials at other boring locations.

#### 4.4

#### MONITORING WELL INSTALLATION AND GROUNDWATER MOVEMENT

Five monitoring wells were installed in September. The locations are shown on Figure 4-1 and location coordinates are presented in Appendix E. These locations were selected to provide hydrological and water quality data and to evaluate the potential for the migration of materials from the site into off-site areas.

##### 4.4.1 METHODOLOGY

The wells were constructed of 2-inch inside diameter polyvinyl chloride (PVC), Schedule 40 flush-joint pipe. Eight-inch hollow stem augers were used to drill the borehole. A record was made of the soils penetrated during the drilling of the boreholes. Five foot long by 2-inch diameter slotted PVC screens were installed in each well. These screens had a slot opening of 0.008 inches. Ten feet of pipe completed the installation. The augers were then withdrawn allowing the water bearing formation to collapse around the screen. The remaining borehole was then backfilled to two feet below the land surface with pelletized bentonite. A concrete stabilizing pad and locking protective outer casing completed the well head.

Copies of the records of each well are presented in Appendix H.

##### 4.4.2 WELL DEVELOPMENT AND TESTING

The wells were developed upon completion by overpumping and surging. The drill rig pump was used to develop the wells. Periodic reversals of the pump served to surge the well. All wells were yielding sand free water upon completion of the development process.

Falling head slug tests were performed on each of the wells. Extremely rapid recovery of the wells was monitored by high speed electronic water level recording equipment. The procedure used generates a series of water level and time data which can be used to estimate the aquifer's hydraulic conductivity. A typical test run information is presented in Appendix H. This information was analyzed using the Hvorslev procedure for falling head slug tests. The Hvorslev procedure is used for water table conditions such as those found at the Johns-Manville site. The equations used are given on the data sheets in Appendix H.

The top casing elevations of the five monitoring wells were determined by standard land survey procedures. Water levels within the wells were measured on three different occasions. This was accomplished using the wetted tape method with a steel survey tape. This information was used to determine the direction of ground water movement. The water levels measured are given in Table 4-4.

CONTINUED — TABLE 4.2 SUMMARY OF RESULTS OF CHEMICAL ANALYSIS

CONTINUED																	
BORING NUMBER	B-6				B-7				B-8		B-9			B-10		Field Blank	
	Surface	Near Surface	11.5-13.0	24-25.5	Field Blank	Near Surface	Near Surface Replicate	16.5 18.0	16.5 18.0 Replicate	29-30.5	At 20	Near Surface	9.0-10.5	29-30.5	Near Surface		At 20
Boring Depth in Feet	Surface	Near Surface	11.5-13.0	24-25.5	Field Blank	Near Surface	Near Surface Replicate	16.5 18.0	16.5 18.0 Replicate	29-30.5	At 20	Near Surface	9.0-10.5	29-30.5	Near Surface	At 20	Field Blank
Chemical Parameter (mg/kg)																	
Chromium, Total	29	5.4	18	6.4	3.6	22	18	14	18	1.8	1.3	28	26	3.8	8.2	4.8	1.2
Lead, Total	2200	330	2000	3900	< 1.0	82	129	< 1.0	-	-	5.4	250	28	6	20	9.6	-
Asbestos	<1	< 1	<1	<1	0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	0
Toluene (U220)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ethyl Benzene	-	-	-	-	-	-	-	-	-	-	-	-	-	0.054	-	-	-
Di-N-Butylphthalate	0.27	0.18	0.21	0.12	0.21	0.33	0.24	0.30	0.18	-	-	-	-	-	-	-	-
1,2-Dichlorobenzene (U070)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1,3-Dichlorobenzene (U071)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3	3.1
Bis(2-Ethylhexyl) Phthalate (U028)	5.2	4.0	72	4.2	81	120	8.8	5.9	-	-	-	0.40	0.20	0.31	-	-	1.0
Di-N-Octyl Phthalate (U107)	-	2.5	30	1.9	47	56	9.3	4.4	0.59	0.58	-	-	-	-	-	-	-
Fluorene	-	.032	0.10	0.031	-	-	0.14	-	-	-	-	0.64	-	-	-	-	-
Fluoranthene	0.28	0.50	0.14	0.12	-	0.29	0.14	-	-	-	-	0.44	-	-	-	-	-
Pyrene	0.33	0.48	0.14	0.11	-	0.35	0.18	-	-	-	-	0.27	-	0.12	-	-	-
Phenanthrene	0.18	0.59	0.19	0.27	-	0.40	0.27	-	-	-	-	0.20	-	0.048	-	-	-
Anthracene	.051	0.21	0.10	-	-	0.11	.082	-	-	-	-	0.20	-	-	-	-	-
Benzo (A) Anthracene	0.23	0.42	-	-	-	14	0.082	-	-	-	-	-	-	0.56	-	-	-
Naphthalene (U165)	0.22	0.16	0.10	0.26	-	0.15	0.16	-	0.20	-	-	-	-	-	-	-	-
p-Chloro-m-Cresol (U039)	-	-	-	-	-	-	-	-	-	-	19	30	27	-	7.9	-	-
Pentachlorophenol (U242)	-	-	-	-	-	-	-	-	-	-	-	0.40	-	-	-	-	-
2,4,6 Trichloro Phenol (U231)	-	-	0.4	-	-	0.90	2.0	-	-	-	-	-	-	-	-	-	-
PCB 1254	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thiram	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Non Detectable																	

- Non Detectable

Table 4-3  
Summary of Engineering Properties

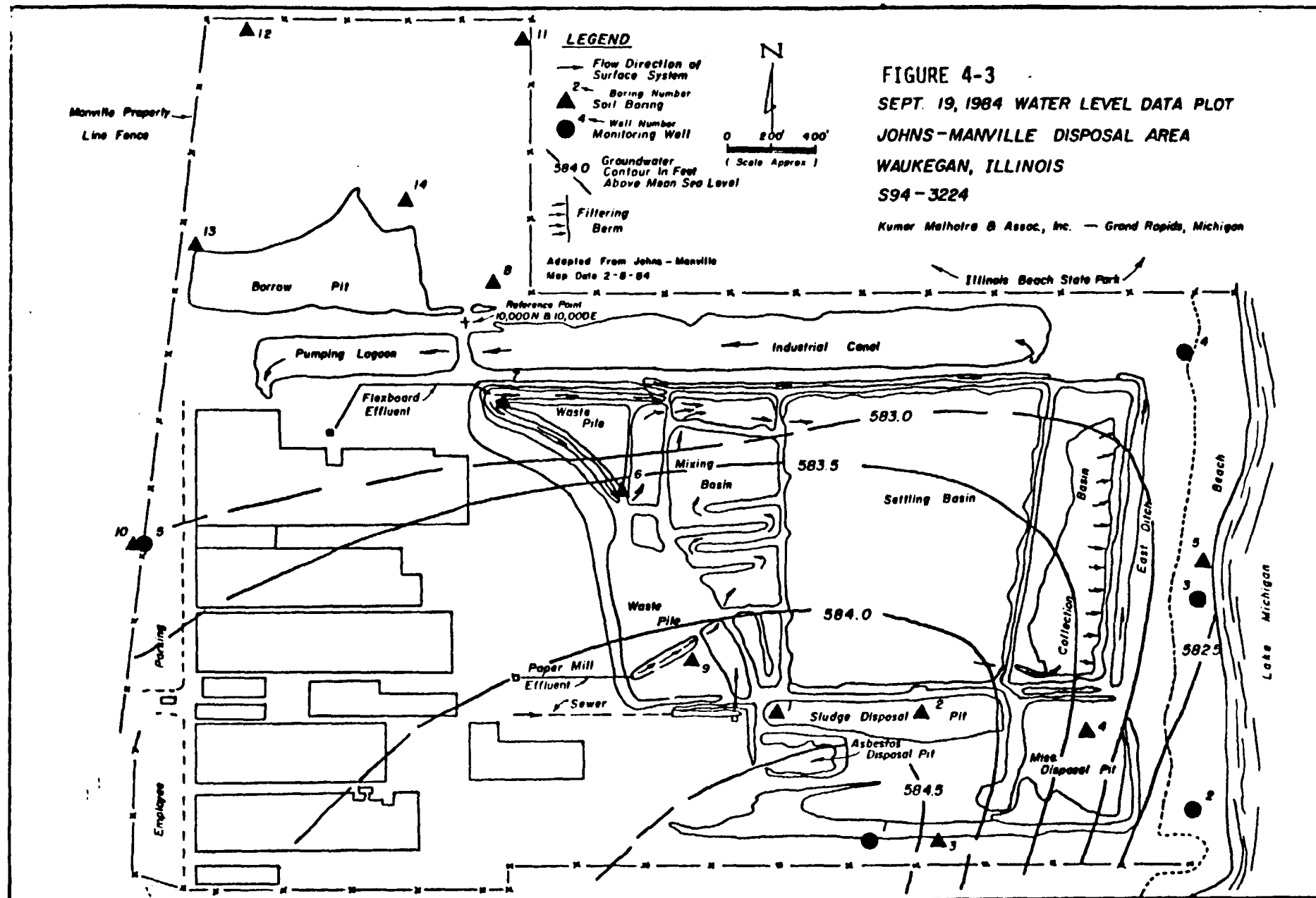
Sample Number	Moisture Content %	<--- Grain Size * ---->			Liquid Limit %	Plastic Limit %	Plasticity Index %	Permeability Cm./Sec. **	Specific Gravity	Material Description:
		Sand %	Silt %	Clay %						
JMW-SS-1-2-2	190.80	2.48	90.83	6.69	200.00	97.60	102.40	$1.83 \times 10^{-5}$	2.19	Waste Sludge, Gray
JMW-SS-1-7-6	135.70	2.75	95.04	2.21	116.50	80.40	36.10	$1.75 \times 10^{-5}$	2.16	Waste Sludge, Gray
JMW-SS-1-16-6	31.05	99.63	0.37	0.00	N/A	N/A	N/A	$3.42 \times 10^{-5}$	2.58	Sand, Silty, Wet
JMW-SS-2-1-1	86.40	7.12	75.26	17.62	137.30	92.50	44.80	$6.90 \times 10^{-5}$	2.36	Waste Sludge, Gray
JMW-SS-2-11-6	115.70	0.00	97.32	2.68	99.80	72.30	27.50	$4.41 \times 10^{-6}$	2.22	Waste Sludge, Gray
JMW-SS-2-16-6	20.60	99.44	0.56	0.00	N/A	N/A	N/A	$5.10 \times 10^{-3}$	2.68	Sand, Silty, Wet
JMW-SS-3-1-1	15.00	98.76	1.23	0.01	N/A	N/A	N/A	$3.10 \times 10^{-2}$	2.51	Sand, Some Cinders
JMW-SS-3-2-2	23.40	96.86	3.14	0.00	N/A	N/A	N/A	$3.10 \times 10^{-2}$	2.29	Sand, Some Cinders
JMW-SS-3-6-6	15.60	0.00	69.18	30.82	18.50	14.30	4.20	N/A	2.68	Clay, Gray, Sandy
JMW-SS-4-2-2	280.10	11.13	74.97	13.90	N/A	N/A	N/A	$7.36 \times 10^{-3}$	2.29	Waste Sludge, White
JMW-SS-4-5-5	138.50	15.48	77.40	7.12	250.00	122.90	127.10	$3.81 \times 10^{-4}$	2.34	Waste Sludge, Gray
JMW-SS-4-8-6	51.60	N/A	N/A	N/A	N/A	N/A	N/A	$9.50 \times 10^{-4}$	2.71	Sand and Wood
JMW-SS-5-4-6	24.40	97.36	2.65	0.01	N/A	N/A	N/A	$7.60 \times 10^{-3}$	2.71	Sand, Fine, Silty
JMW-SS-6-1-1	28.00	N/A	N/A	N/A	N/A	N/A	N/A	$5.30 \times 10^{-4}$	2.26	Sand and Cinders
JMW-SS-6-2-2	13.90	93.43	6.57	0.00	N/A	N/A	N/A	$5.30 \times 10^{-4}$	2.19	Sand and Cinders
JMW-SS-6-7-6	138.50	24.35	72.62	3.03	138.50	70.10	68.40	$6.53 \times 10^{-5}$	2.47	Waste Sludge, White
JMW-SS-6-12-6	23.80	99.82	0.17	0.01	N/A	N/A	N/A	$5.80 \times 10^{-3}$	2.82	Sand, Fine, Silty
JMW-SS-7-2-2	24.10	98.81	1.19	0.00	N/A	N/A	N/A	$4.50 \times 10^{-4}$	2.30	Sand and Sludge
JMW-SS-7-9-6	304.20	51.19	40.96	7.85	232.00	136.30	95.70	$1.86 \times 10^{-5}$	2.43	Sludge, White
JMW-SS-7-14-6	15.6	98.10	1.90	0.00	N/A	N/A	N/A	$2.20 \times 10^{-4}$	2.74	Sand, Fine, Wet
JMW-SS-8-3-6	31.00	97.35	2.65	0.00	N/A	N/A	N/A	$1.70 \times 10^{-3}$	2.73	Sand, Fine, Silty
JMW-SS-9-2-2	92.20	3.67	93.35	2.98	89.20	67.50	21.70	$2.79 \times 10^{-6}$	2.64	Waste Sludge, White
JMW-SS-9-6-6	121.75	2.37	94.90	2.73	79.30	60.30	19.00	$3.69 \times 10^{-6}$	2.61	Waste Sludge, White
JMW-SS-9-14-6	29.10	99.72	0.28	0.00	N/A	N/A	N/A	$1.80 \times 10^{-2}$	2.72	Sand, Fine, Silty
JMW-SS-10-2-2	2.1	98.75	1.25	0.00	N/A	N/A	N/A	$8.90 \times 10^{-3}$	2.66	Sand, Fine, Moist
JMW-SS-10-4-6	30.7	98.12	1.88	0.00	N/A	N/A	N/A	$5.10 \times 10^{-3}$	2.74	Sand, Fine, Wet

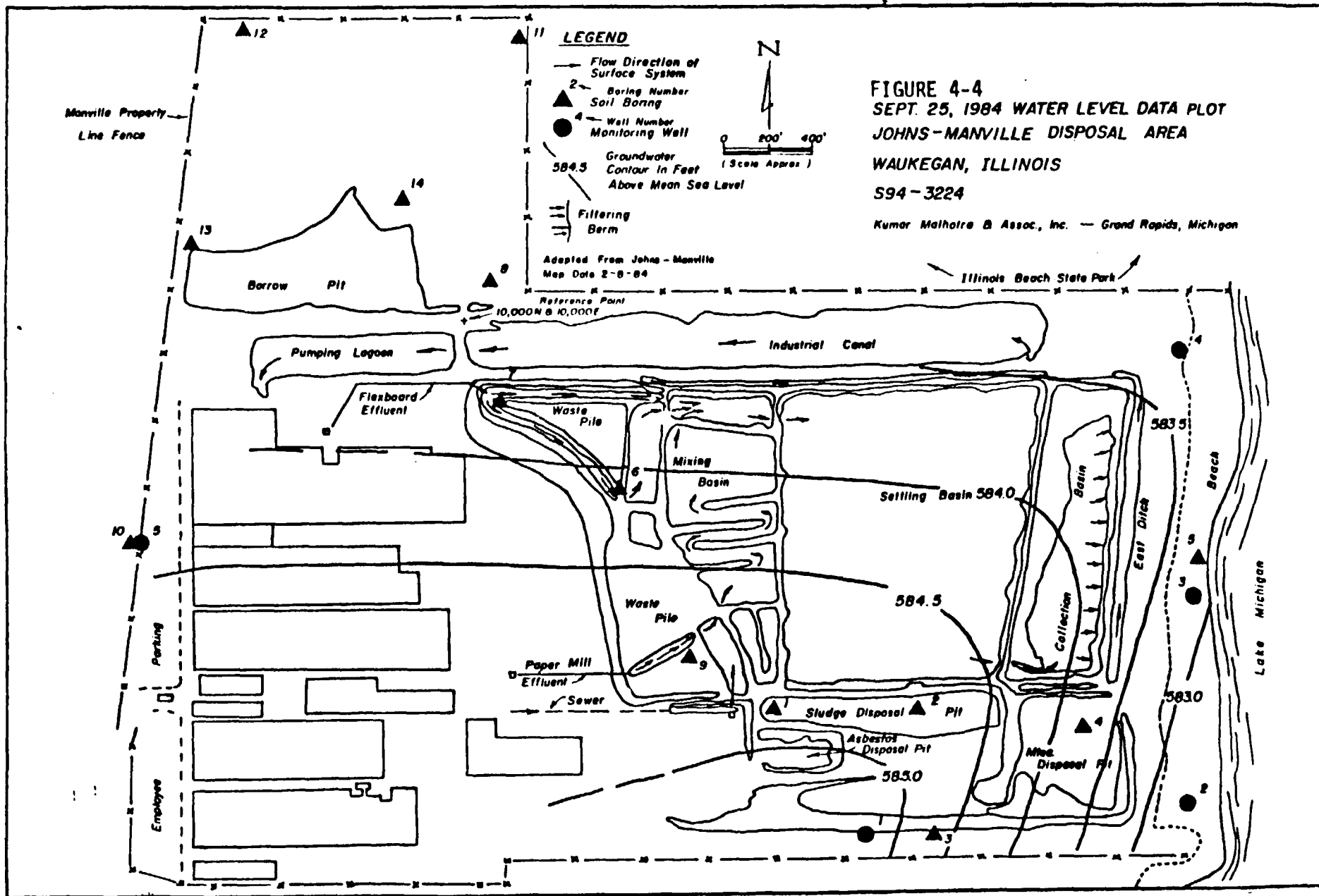
\* Sieve or hydrometer procedure used as appropriate.

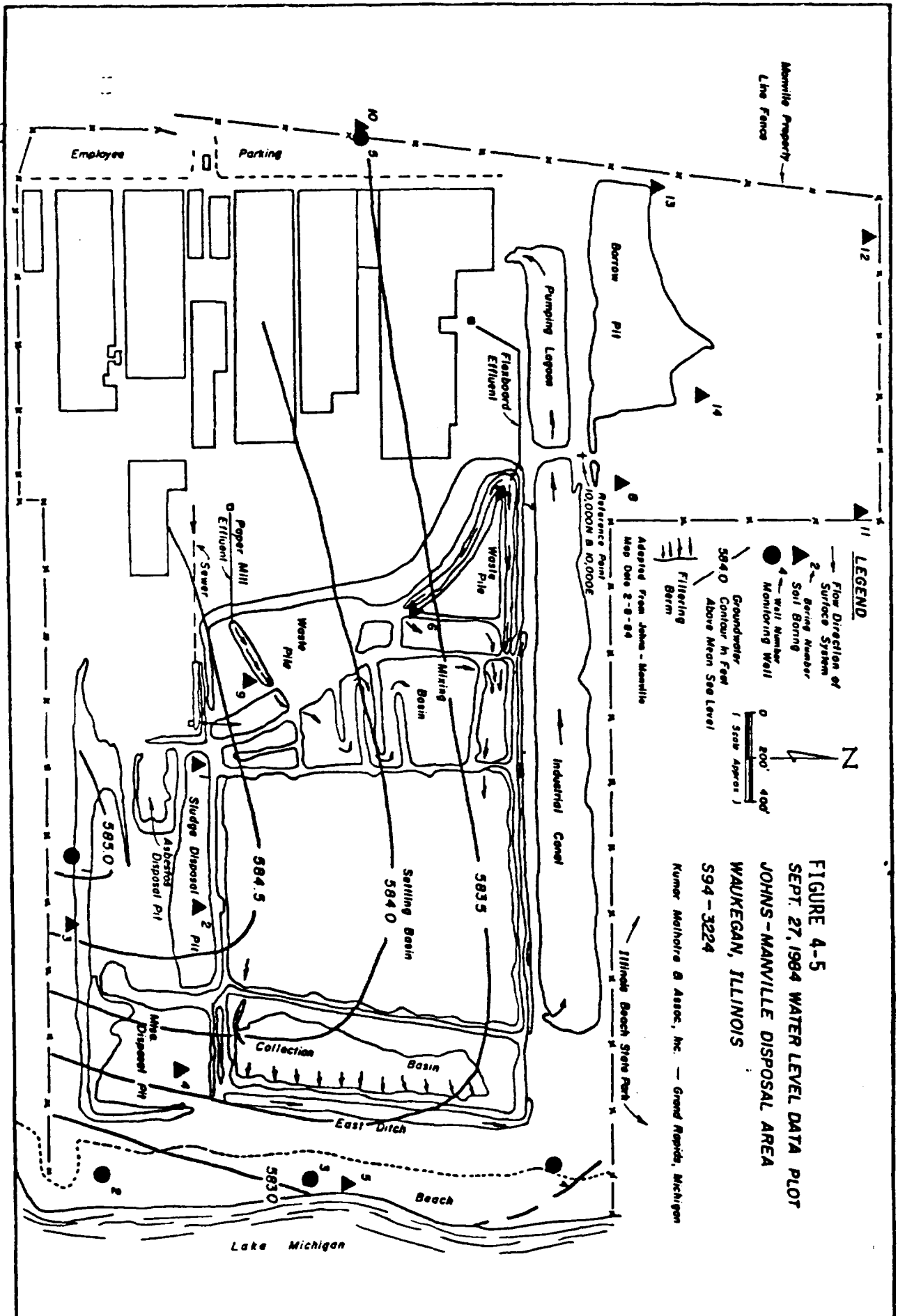
\*\* Scientific notation,  $2.65 \times 10^{-4}$  = 2.65 times 10 to the -4 power.

N/A Analysis not appropriate for this sample.

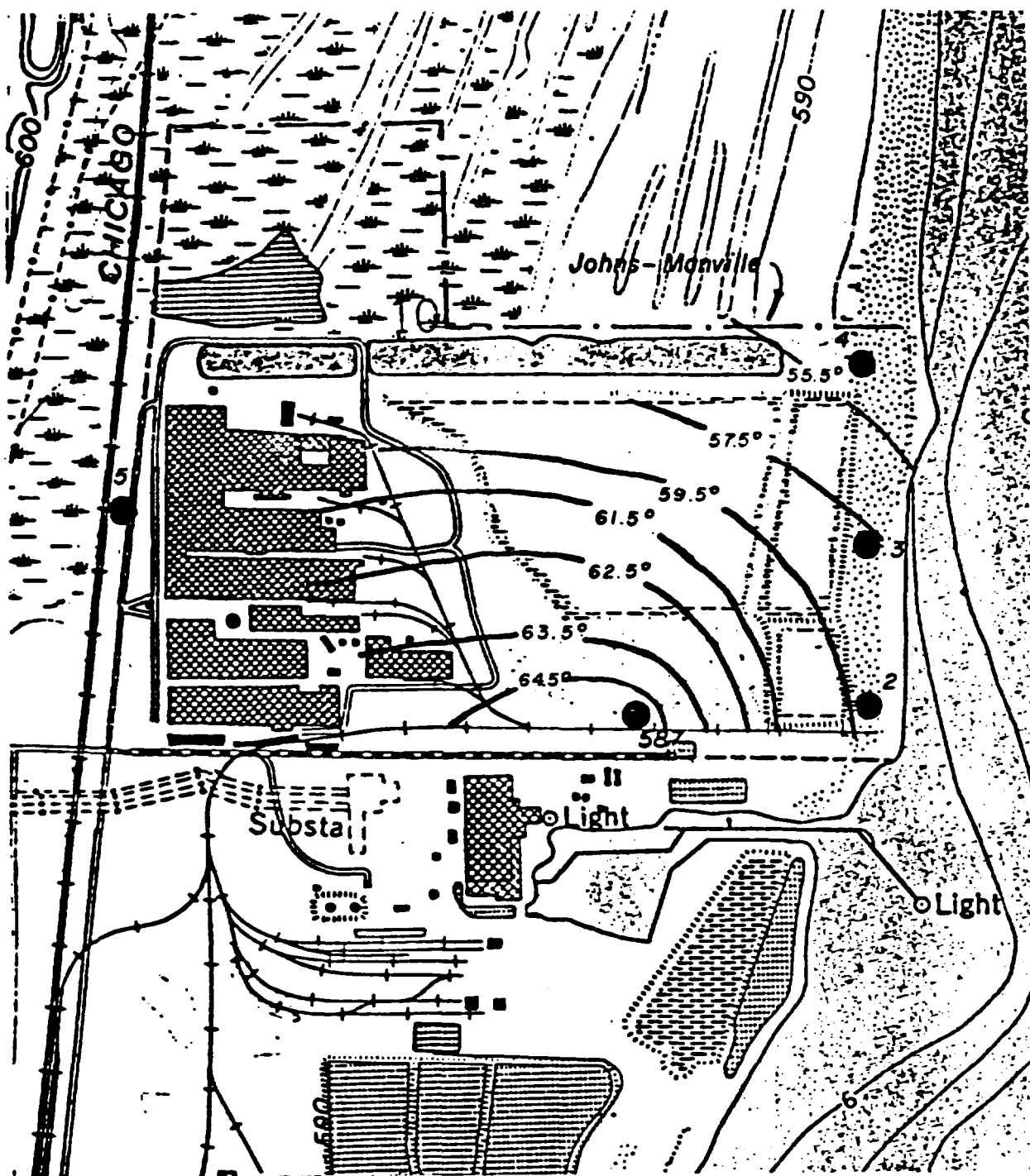








**FIGURE 4-5**  
**SEPT. 27, 1984 WATER LEVEL DATA PLOT**  
**JOHNS-MANVILLE DISPOSAL AREA**  
**WAUKEGAN, ILLINOIS**  
**S94-3224**  
 Kumer Mulheir & Assoc., Inc. - Grand Rapids, Michigan



# **LEGEND**

- Well Number
- Monitoring Well
- Temperature Contour
- °F

N

0 500' 1000'

FIGURE 4-6  
GEOTHERMAL FLOW MAP  
JOHNS-MANVILLE DISPOSAL AREA  
WAUKEGAN, ILLINOIS  
S94-3224

Consolidated Edison has a coal fired electrical generation plant immediately south of the Johns-Manville site at Waukegan. This power facility is a source of heat which is disposed of in cooling water. The cooling water is obtained by pumping from Lake Michigan offshore of the facility. The heated water is then released into a canal which parallels the south boundary of the Johns-Manville site. This water may be moving into the ground by virtue of having a higher elevation in the canal than the surrounding ground water. The temperature contours shown in Figure 4-6 closely parallel the water table phreatic surface contours shown in Figures 4-3, 4-4 and 4-5. Heat flow, like ground water flow, is generally from the south site boundary toward the north and then east. This conforms to the direction of ground water movement obtained using groundwater level measurements. The use of about 4.3 mgd of recycled water by Johns-Manville plant from the industrial canal located on the northern boundary of the site is also likely to influence the groundwater movement in the northerly direction as observed.

#### 4.5 GROUNDWATER SAMPLING AND ANALYSIS

Groundwater samples were collected in September, 1984 and analysed to determine if groundwater contamination was occurring. One round of samples from the five new monitoring wells plus a duplicate sample and a field blank were collected. Figure 4-1 shows the locations of the five wells.

Three well volumes of water were bailed from each well prior to sampling. The same stainless steel bailer was then used to collect the samples. The bailer was decontaminated between wells by rinsing in de-ionized water, followed by an acetone rinse and a hexane rinse. Sample labels were completed and attached to the bottles as the samples were collected. The labels followed the procedure outlined in the project work plan and included the well number, date and time of sampling separate from the sample designating number as an added cross check for the laboratory to assure sample security. Table 4-5 summarizes the sample bottles, procedures and preservatives. All samples were cooled to 4 degrees Centigrade on site and transported to the Canton Laboratory in Ypsilanti, Michigan within 24 hours.

##### 4.5.1 SAMPLE ANALYSIS AND RESULTS

Temperature, Specific Conductivity and pH were tested in the field using a Presto-Tek Poly-Pram portable instrument. Appropriate calibrations were made prior to beginning the testing and again upon completion. The results of these field tests are given in Table 4-6. All asbestos, organic and inorganic analyses of samples were performed by Canton Laboratory. A copy of the test results is presented in Appendix F. A summary of the results is

TABLE 4-5

## GROUNDWATER SAMPLE BOTTLES, PROCEDURES AND PRESERVATIVES

Sample	Bottle Size	Filtered?*	Preservative	Remarks
General Chem. & Pesticides	1 Gallon	No	None	Solvent rinsed and dried
Volatile Org. (2 bottles)	40 ml**	No	None	Duplicate every well
Metals	500 ml	Yes	1+1 Nitric Acid	
Sulfide	500 ml	Yes	Zinc Acetate	
Cyanide	500 ml	Yes	10N NaOH	
Ammonia & TOC	500 ml	No	Sulfuric Acid	
Mercury	500 ml	Yes	1+1 Nitric Acid & Potassium Dichromate	
Asbestos	500 ml	No	None	

\* Filtering done with 0.45 micron vacuum filter into a solvent rinsed glass container

\*\* Sealed with Teflon-lined caps

TABLE 4-6

## GROUNDWATER SAMPLE FIELD TEST RESULTS

Well No.	Date	Time	Temperature (C)	Specific Conductivity*	pH
1	9-26-84	15:55	18.4	1203	7.52
2	9-26-84	07:44	14.9	988	7.00
3.	9-26-84	09:51	14.3	610	7.29
4	9-26-84	11:35	13.2	629	7.08
5	9-26-84	13:35	16.2	764	7.08
Blank	9-26-84	17:28	11.7	12.8	5.12

\* Micromho's

presented in Table 4-7, especially of parameters which were observed in levels higher than their detectable levels.

Asbestos in the water was determined by using an adaptation of NIOSH method for air asbestos analysis using polarized light microscope at 100x magnification for identification of asbestos fibers and phase-contrast microscope at 400x magnification for counting fibers. Details of this method are presented in Appendix G. This method has been accepted by Michigan Department of Natural Resources for routine analysis of water samples for asbestos fibers. In addition, water samples, including field blank and replicate were analyzed by electron microscopy (using USEPA recommended procedures) by EMS Laboratories, Hawthorne, California. The results of asbestos analysis by electron microscopy along with the laboratory quality control data were submitted to USEPA as technical memorandum M-1 in June, 1985, and are included in Appendix J of this report, Volume II.

Details of the analytical and the quality control procedures normally used by this laboratory were furnished to USEPA prior to the approval of the site work plan. Specific quality control data collected during analytical work for this site is presented in Appendices G and J.

SUMMARY OF MONITORING WELL TEST RESULTS . .  
TABLE 4 - 7

Sample or Well Number	1	2	3	3 (Duplicate)	4	5	Field Bank	Primary Drinkin Water Standar
Chemical Parameter in mg/L*								
Asbestos	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	-
Thiram	<.005	<.005	<.005	<.005	<.005	<.005	<.005	-
Chromium, Total	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05
Lead Total	0.014	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	0.05
Barium, Total	0.35	0.38	0.21	0.19	0.18	0.16	<0.10	1.0
Copper, Total	0.02	0.03	0.02	<0.01	<0.01	0.07	<.01	-
Arsenic, Total	0.029	0.022	0.020	0.023	0.021	<0.002	<0.002	0.05
Boron	0.97	0.71	0.41	0.34	0.35	0.28	0.47	-
Total Organic Carbon	7.2	6.8	3.1	3.1	3.5	2.8	110**	-
Iron, Total	<0.02	0.86	0.13	0.12	0.08	1.6	<0.02	-
Manganese, Total	0.15	0.20	0.09	0.09	0.02	0.21	<0.01	-
Zinc, Total	0.01	0.03	<0.01	0.01	<.01	0.24	<0.01	-
AmmoniaNitrogen as N	2.3	0.9	1.6	1.6	0.6	1.6	<0.1	-

\* All other Parameters were at non-detectable levels.

\*\* Distilled water blank was stored in a plastic container

- Not available

N.D. Not Detected



#### 4.5.2 DISCUSSION OF RESULTS

Asbestos fibers were not observed in any of the samples by phase contrast microscopy. Results by electron microscopy have identified presence in the ground water in the range of 6 to 12 million fibers per asbestos in liter. Analysis of Lake Michigan water samples by electron microscopy also showed similar asbestos fiber concentrations (5.5 to 19 million fibers/l). These observed concentrations of asbestos fibers in the ground water and Lake Michigan water samples are similar to those reported in the literature for tap water and commercial beverages (see Appendix J). Traces of lead, barium, copper, arsenic, boron, iron, manganese and zinc were detected in some of the samples. All these compounds were present in levels below the drinking water standards. The field blank showed an unusually high level of TOC (Total Organic Carbon). This is likely due to the storage of blank distilled water in a plastic jar prior to its use for the field blank. The TOC values were in the normal range for drinking water. Ammonia nitrogen levels were higher than those found in drinking water but were similar to those normally encountered in shallow groundwater in developed residential/commercial/industrial areas.

#### 4.6 WATER BALANCE STUDIES

Johns-Manville conducted water balance survey at the Waukegan, Illinois plant in January, 1984. A report was prepared in April, 1984 and submitted to USEPA. This section presents a brief summary of the methodology and findings of the water balance survey.

##### 4.6.1 METHODOLOGY

Figure 4-7 is a schematic diagram of the water flow system at the Waukegan facilities and shows the flow measuring locations where flow recorders were used during the water survey. Daily flow readings were taken from January 2 to January 31, 1984. Evaporation from approximately 57 acres surface area of process water settling basins was estimated using United States Weather Bureau information and the temperature drops observed between settling basins influent and effluent flow. Water use in boilers and products was estimated and an over all mass balance was made for the study period.

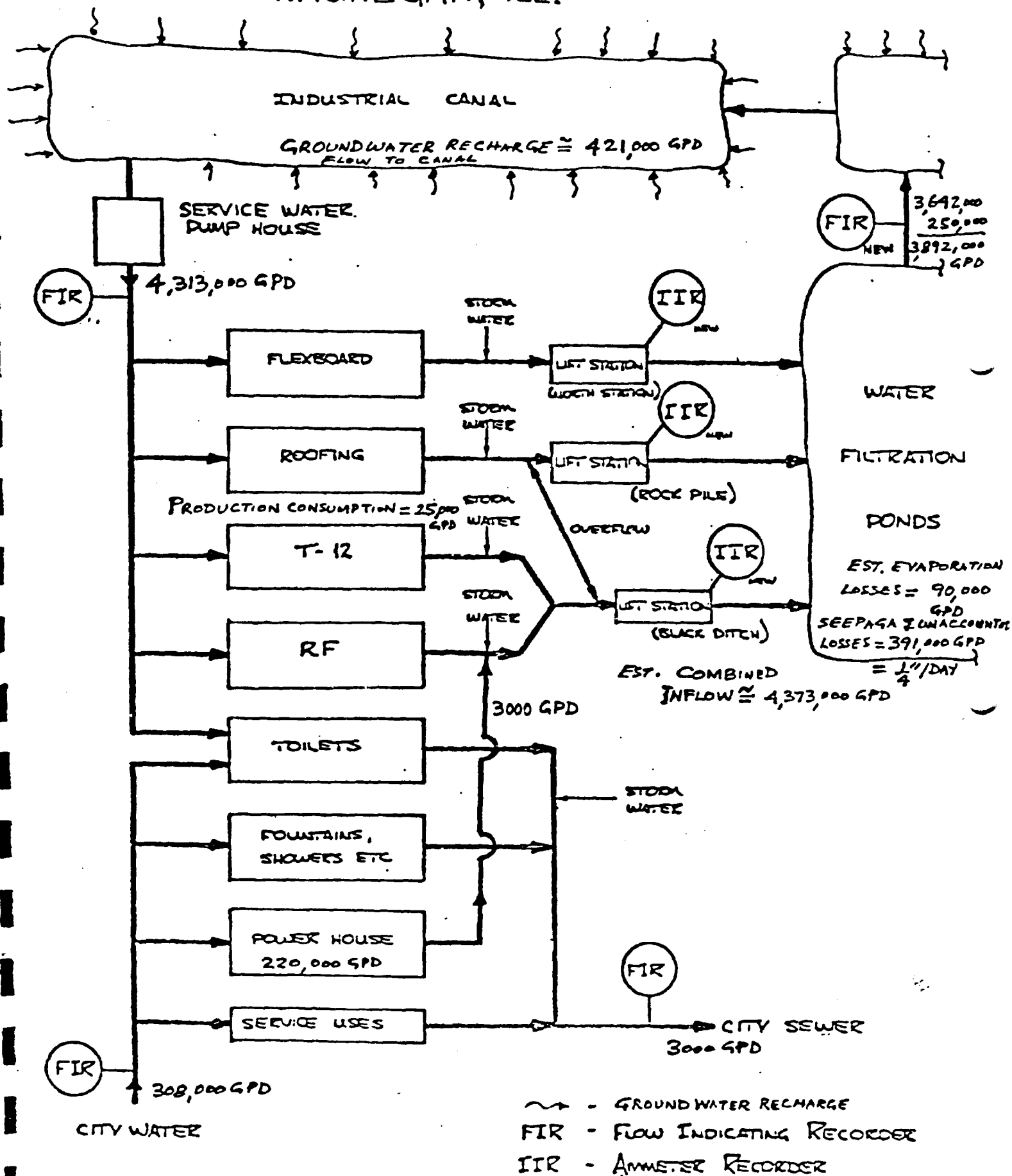
##### 4.6.2 SUMMARY OF FINDINGS

Water balances data is summarized on Figure 4-7. The main findings of the study are as follows:

- o On the average, 308,000 gpd of city water and 4,313,000 gpd of service water (treated process water + make up groundwater recharge) is supplied to the plant.
- o 25,000 + gpd is estimated to be used through product consumption and 220,000 gpd through boiler/steam uses.

FIGURE 4-7

# SCHEMATIC WATER FLOW DIAGRAM AND SURVEY MONITORING LOCATIONS WAUKEGAN, ILL.



- o 3,000 ± gpd is discharged to city sewers.
- o 4,373,000 gpd is estimated to be discharged to treatment ponds.
- o 90,000 ± gpd is estimated to be lost by evaporation and 391,000 gpd through seepage and unaccounted means.
- o 3,892,000 gpd flows to industrial canal and 421,000 gpd plus evaporation losses enters this canal from groundwater in its surroundings.
- o Seepage loss of 391,000 gpd is equivalent to 1/4"/day over 57 acres of ponds. This loss is typical for clay-lined ponds. Groundwater monitoring well data has not shown any adverse impact because of this seepage.
- o Most of the seepage flow is anticipated to serve as the recharge for the industrial canal and some may be moving towards Lake Michigan.
- o Seepage flow is not anticipated to move beyond industrial canal in the northerly direction because the recharge flow needed is more than the seepage flow and this excess has to flow into the industrial canal from its surrounding areas, mainly north of the canal.

#### 4.7

#### AIR SAMPLING AND ANALYSIS

Air sampling and analysis was conducted by Ontario Research Foundation. A report containing the details of sampling and analysis procedures, observed results of on-site and off-site air samples and quality assurance analyses was prepared in February, 1985. The executive summary of this report is included in this Section, and the remaining report is presented following Section 5.0 on endangerment assessment.

## 4.7.1

EXECUTIVE SUMMARY

During October and November, 1984, an air sampling program was conducted in the vicinity of the landfill of the Johns-Manville Sales Corporation manufacturing facility at Waukegan, Illinois. Background samples were also collected at three off-site locations. The air sampling plan stipulated that five samples should be collected at various locations on the landfill, and that three off-site samples should be collected concurrently. The sampling was to be repeated on five separate days, with the sampling period commencing simultaneously with the day shift of the plant. The sampling period was specified as 12 hours.

The samples were analyzed according to the draft EPA analytical method, based on electron microscopy. Analytical quality assurance samples, including duplicates, replicates and inter-laboratory samples, were also analyzed.

The majority of the results obtained were close to the detection limits of the measurement technique, but some values were higher than this. The detection limit of the method, under the optimum sampling conditions in use, was about 0.003 fiber/milliliter. Amphibole fiber concentrations found in the on-site samples were not different from those determined in the off-site samples, and were less than those found for the blank samples. The average of the upper 95% confidence limits for the 25 on-site samples was 0.005 fiber/milliliter, compared with that for the 14 off-site samples of 0.0054 fiber/milliliter. The corresponding value for the 4 blank filters was 0.008 fiber/milliliter. Currently available blank filters are known to have a low level of both amphibole and chrysotile contamination, which elevates the detection level for fibers of all lengths. There are usually no contamination fibers of either variety which are longer than 5 micrometers.

EXECUTIVE SUMMARY - continued

For the on-site samples, chrysotile fiber concentrations of up to 0.065 fiber/milliliter were obtained, with a corresponding 95% confidence interval of 0 - 0.15 fiber/milliliter. For chrysotile, the average of the upper 95% confidence limits for the 25 on-site samples was 0.022 fiber/milliliter, compared with that for the 14 off-site samples of 0.0049 fiber/milliliter. It should be noted that the corresponding result for the 4 blank filters was 0.010 fiber/milliliter, about 50% of the on-site value for chrysotile.

If the interpretation were to be made in terms of fibers longer than 5 micrometers, all of the fiber concentrations of both varieties of fibers were at the detection limit or very close to it. For amphibole fibers, the average of the upper 95% confidence limits for the 25 on-site samples was 0.0031 fiber/milliliter, compared with that for the 14 off-site samples of 0.0028 fiber/milliliter, both of which are clearly indistinguishable from the corresponding average of 0.003 fiber/milliliter for the 4 blank filters. For chrysotile, the average of the upper 95% confidence limits for the 25 on-site samples was 0.0046 fiber/milliliter, compared with that for the 14 off-site samples of 0.0028 fiber/milliliter. These values are close to the corresponding average of 0.0030 fiber/milliliter found for the 4 blank filter measurements.

A significant problem in the interpretation of these results is caused by the non-uniformity of the fiber deposit on the collection filters. This is not seen when results are low, because fibers have to be present in order to detect the non-uniformity, but at higher concentrations the fiber counting results indicate a gross departure from a Poisson distribution, and yield correspondingly high 95% confidence intervals.

EXECUTIVE SUMMARY - continued

Although the samples were notably non-uniform, there was substantial agreement between the various quality assurance samples. In some cases the results were within the accepted analytical precision (plus or minus 50%), even if statistically they could be discriminated from each other. The quality assurance samples were all in agreement concerning the low concentration of fibers longer than 5 micrometers.

## 5.0 ENDANGERMENT (RISK) ASSESSMENT

This section presents endangerment assessment (EA) of the Johns-Manville, Waukegan, Illinois disposal area based on the information gathered through remedial investigation and reviews of available site data. The EA has two main objectives:

- o To provide an evaluation of the level of endangerment (risk) to human health and the environment posed by potential or actual release of hazardous substances from the waste disposal site.
- o To provide a basis to differentiate among alternatives in selecting recommended remedial measures.

## 5.1 PHYSICAL DESCRIPTION OF THE SITE AND SITE HISTORY

Section 3.0 presents a brief description of the physical characteristics and history of the site. A chronological survey of the site is included in Appendix A. An assessment of waste materials and contaminants brought to the site and the site management practices are also included in Section 3.0.

## 5.2 SITE CONTAMINATION/OFF-SITE CONTAMINATION

Air, soil, and groundwater samples were collected on and around the disposal area. The details of these investigations are discussed in Section 4.0. Contaminants specifically identified for investigation at the site were asbestos, lead, thiram, chromium and xylene. In addition, an investigation for priority pollutants was conducted on the soil and groundwater samples. Of these contaminants, only asbestos and lead are discussed in this section. Thiram and xylene were not detected in the soil or groundwater. Chromium levels were low or below detection.

### 5.2.1 SOIL CONTAMINATION

#### Asbestos:

Asbestos fibers were present in on-site waste materials and sludges. Most of these were in the encapsulated form incorporated into waste products with cement and other binding materials. Friable bulk asbestos fibers in the surface, near surface and subsurface soil samples were found to be less than one percent. Off-site soil samples did not contain any waste material such as cement-asbestos pipe or sheet fragments. Bulk asbestos fiber content in these samples was also less than one percent.

Lead:

The active waste disposal areas showed concentrations in the range of 13.0 to 4700 mg/kg. The high concentrations of lead appear to be present in a layer of waste materials approximately between elevations 585 and 600 generally located in the disposal areas on the south side of the site. Soils underneath the waste materials deposited on and around the active waste disposal areas and in the off-site sampling locations contained background levels of lead, generally less than 20 mg/kg.

5.2.2 GROUNDWATER CONTAMINATION

Asbestos:

Asbestos fiber concentrations in the range of 6 to 12 million fibers per liter were observed in groundwater samples from the monitoring wells located around the periphery of the waste disposal site. Such fiber concentrations are in the same range observed in Lake Michigan near shore and deep water samples, and similar to fiber concentrations reported in the literature for tap water and commercial beverages.

*Is this considered as a safe level?*

Lead:

Traces of lead and other metals were detected in some of the samples, but these observed levels were below the drinking water standards.

5.2.3. SURFACE WATER CONTAMINATION

No direct discharge to surface water exists except of the storm water run-off from the paved areas of the plant. Surface run off from the waste disposal site is mostly intercepted by the waste disposal pits, and basins used for the process waste water treatment and recycling. No surface water contamination in the vicinity of this site has been reported so far. Asbestos fiber concentrations in the Lake Michigan near shore and deep water samples are within the range reported in the literature for surface water, tapwater and commercial beverages.

5.2.4. AIR CONTAMINATION

Asbestos:

Amphibole fiber concentrations in on-site samples were not different from those in off-site or blank samples. Chrysotile fiber concentrations for fibers of all lengths in on-site samples were somewhat higher than off-site samples, ranging from 0.003 fiber/ml to 0.065 fiber/ml. The average of the upper 95% confidence limits for these



on-site samples was 0.022 fiber/ml. For fibers longer than 5 micrometers, all the values were either at the detection limit or very close to it, ranging from 0.003-0.006 fibers/ml. The average of the upper 95% confidence limits for these samples was 0.0046 fibers/ml.

#### Lead:

The release of lead to the atmosphere is expected to be minimal. Air monitoring for lead was not requested prior to initiating the remedial investigation but is planned for summer of 1985 at the request of USEPA.

### 5.3 ENVIRONMENTAL FATE AND TRANSPORT

This section summarizes the chemical and physical properties of lead and asbestos. These properties include decomposition and transformation rates in the environment. The pathways and the actual and potential of migration of these contaminants to the environmental resources on and around the site are also presented in this section.

#### 5.3.1 CHEMICAL AND PHYSICAL PROPERTIES

##### Asbestos:

"Asbestos" is a generic term used to describe a family of naturally occurring hydrated silicate minerals which break down into fibers when crushed or processed. Though there are a number of such materials in nature and exposure to humans to each of them may occur, there are only four that are of commercial importance. These are chrysotile, a serpentine mineral; and crocidolite, amosite and anthophyllite which are members of the amphibole mineral group. Tremolite and actinolite are two other members of the amphibole group which at this time are not of commercial importance. Of these, tremolite is of biological importance since it has been shown to be biologically active in animal experimentation and at times it may occur as a contaminant of other forms of commercially used asbestos and also of talc. Its presence as a contaminant may contribute materially to the overall biological effects that have been observed in settings where the exposure has been to one of the four commercially used forms of asbestos.

##### Chrysotile:

This is a hydrated magnesium silicate, the fibers of which have a white or greenish color and are flexible and soft. Of importance is the fact that it contains 13.0% water of crystallization and when this is driven off by higher temperatures, the fibers lose their tensile strength and readily disintegrate into shorter and nonfibrous fragments. Chrysotile fibers have a curly, wavy or

serpentine shape which causes their aerodynamic diameter to be greater than their actual physical diameter and thus reduces the ease or ability with which they penetrate into the more distal parts of the lung structure. Chrysotile fibers are readily destroyed by acid.

#### Crocidolite:

This is a sodium iron silicate of a bluish color. The fibers are relatively inflexible, stiff and harsh. They are straight or non-curly in character and are quite resistant to acids.

#### Amosite:

This is a ferrous magnesium silicate of brownish yellow coloration. The fibers are straight and stiff or harsh and resistant to acids.

#### Anthophyllite:

This is a magnesium silicate containing a smaller amount of iron than does amosite. It is rather more fragile than the other commonly used forms and is of a brownish or off-white color. The fibers are of a white to greenish color and are relatively acid resistant.

The amphiboles in contrast to chrysotile, are quite resistant to heat and maintain an integrity of their shape at higher temperatures.

The physical nature of all of the types of asbestos is such that the aggregates or masses of crystalline structure will cleave longitudinally producing fragments of fiber shape which become progressively thinner when manipulated. In contrast to amphiboles, chrysotile aggregate is composed of bundles of true separate and individual fibrils that are very thin, of the order of 0.01 micrometers and not amenable to further longitudinal splitting. The ultimate diameter obtainable by such progressive cleavage is 0.01 micrometer for chrysotile and 0.10 for the amphiboles.

While the pure forms of asbestos have rather well defined chemical formulations, it should be noted that the fibers ultimately used in commercial or manufacturing processes often contain surface contamination by trace metals such as nickel, chromium, cobalt and manganese derived from equipment used in separating and processing the fibers.

#### Lead:

Lead is an acid-soluble metal that exists in three... oxidation states: 0, 2+, and 4+. Lead occurs in ore deposits as three minerals; PbS (lead sulfide or galena),

$\text{PbSO}_4$  (lead sulfate or anglesite), and  $\text{PbCO}_3$  (lead carbonate or cerussite). The natural minerals and metallic lead are relatively insoluble, but some lead compounds produced industrially are soluble.

Metallic lead has a specific gravity of 11.35, is non-combustible, resists corrosion and is a poor electrical conductor. Its solubility decreases at higher pH. Lead that is leached from natural minerals is generally not very mobile in ground or surface waters because it combines with carbonate or sulfate to form insoluble compounds, or becomes absorbed to ferric hydroxide. Lead reaches the aquatic environment from atmospheric sources (precipitation and dust), street run-off (leaded gasoline exhausts) and industrial wastewater discharges. Naturally high concentrations also occur in some heavily mineralized areas.

### 5.3.2 CHEMICAL TRANSFORMATIONS/DEGRADATIONS

#### Asbestos:

Reference has already been made to the effects of heat and acids on various forms of asbestos. These have been demonstrated to be of importance. The nonfibrous residue of heat treated chrysotile is inert in experimental animals. It has been shown that chrysotile from which appreciable portions of magnesium have been leached by weak acids, loses its carcinogenic influence in the rat intrapleural injection model.

Extensive experimentation in animals has clearly demonstrated that the fibrogenic and carcinogenic power of asbestos as well as some other durable fibers is strongly related to fiber dimensions. Fibers that are shorter than 8.0 micrometers regardless of diameter and those thicker than 1.0 micrometers regardless of length possess little or no capacity to be fibrogenic or carcinogenic. The third factor of importance is that the fibers need to be durable in tissue milieu, though the length of time they must persist in order to evoke fibrosis or be carcinogenic has not been clearly shown.

Chrysotile fibers apparently undergo a marked change in their surface qualities and a reduction in length by fragmentation as a consequence of residence time in human and animal lung tissue. This may be the case, although to a much lesser degree, for amphibole fibers. They tend to persist unchanged.

### Lead:

Lead has a high affinity for organic ligands of dead and living flora and fauna. This property, combined with the ready formation of sulfates and carbonates, generally precludes its movement in aquatic media. However, industrial and other man-made sources have been sufficient to increase concentrations of lead in most surface waters in populated areas. Alkaline soils reduce the solubility of lead mainly by encouraging the formation of lead carbonates whose solubility is very low. Metallic lead can oxidize in the environment and combine with sulfides, sulfates, carbonates and phosphates normally encountered in the environment.

### 5.3.3. CONTAMINANT MIGRATION

Site topography, hydrologic setting, air and soil analysis are discussed in details in Sections 3.0 and 4.0. This section presents a summary of the site characteristics as they affect the migration and fate of lead and asbestos in the environment through the following pathways (routes).

#### Surface Water

The waste disposal activities are concentrated in an area which is graded to direct all surface run off from the site to waste disposal pits. Run-off from other areas of the site flows to process waste water settling and recycling basins. The permeability of the surface and near-surface soils at the site are in the range of  $5 \times 10^4$  to  $5 \times 10^2$  cm/sec. Therefore, a significant portion of the total precipitation (about 33 inches/yr) on the site percolates to the ground water. The site is not subjected to flooding or wave action erosion by Lake Michigan water level fluctuations. East ditch and industrial canal prevent site run-off, if any, from going into Lake Michigan water or wet-lands to the immediate north of the site. Lake Michigan water line is isolated from the site by approximately 400' wide strip of sandy soils with low level shrubbery. This strip provides an added protection to Lake Michigan water from surface run off from the site.

#### Ground Water

There is a superficial sand layer 25 to 39 feet thick across the site from west to east as shown in Figure 4-2. This lies over a clay layer which is estimated to be 50 to 75 feet thick dipping from west to east and extending underneath the lake shore into Lake Michigan. The sandy layer acts as an unconfined water table aquifer and intercepts all water that seeps through the waste materials and settling basins at the site. Most of the deposited waste materials at the site serve as an unsaturated zone.

Ground water flows ultimately to the east into Lake Michigan.

There are six wells within a one mile distance of the waste disposal site. Four of these are on Johns-Manville property and are not used for drinking water supply. The fifth well is a deep well in the sandstone formation, and the sixth is in the dolomite aquifer. All of these wells are located upgradient from the ground water flow at the site.

The majority of the lead appears to be combined with cementitious alkaline materials and not readily leachable to the ground water. This is especially evidenced from Well 1 data. This well is in close proximity of Boring 3 where high levels of lead were observed in surface and near surface soil samples. Yet the ground water sample at this location showed only trace of lead. Much of the asbestos waste is in encapsulated or bound form. Moreover, free fibrous asbestos does not migrate through soil and therefore is not available to contaminate groundwater. No evidence of ground water contamination from the seepage of process water (from the settling basins) has been observed. The recycling of service water from the basins to the north of the site appears to be preventing migration of ground water away from the site towards off-site locations, to the north or south of the Johns-Manville property. The ground water from the site is moving to Lake Michigan and does not appear to be contaminated.

#### Air

The management of the waste disposal activities at the site appear to be controlling the release of fugitive dust to the atmosphere around the site. Occasional incidents of wind blown paper and refractory insulation cuttings have been observed. Such incidents are minimized through the use of cyclone and snow fencing and berms around the pits. Site air contained asbestos fibers of all lengths at levels somewhat higher than those observed at the off-site locations. However, the observed concentrations for fibers longer than 5 micron were at or near the detection limit. The site is composed of settling and water recycling basins and dry disposal areas. The emission of lead and asbestos fibers, if any, would originate mainly from the dry disposal areas. These areas are not accessible to public and are well isolated from residential areas. There is no residential dwelling within 1.0 km radius of the disposal areas. Within 0.5 mile radius of the site, there are about 1800 adult workers during the day shifts and about 450 workers during the night shift. No odor nuisance exists at the site.

## Direct Contact

The site is a fenced and managed disposal facility and is thus not easily accessible. However, the possibility of direct contact with the waste of public does exist to those who trespass the area from the lake shore edge of the site. No such contacts with the waste materials at the site have been reported.

## Fire and explosion

This route of contaminant migration is less likely as the wastes disposed at the site are generally non-combustible and do not contain explosive materials. On rare occasions, accidental discharge of hot glass has caused smoldering of waste cuttings and generation of smoke at the waste disposal area. In all such accidents the plant staff working at the disposal area has been able to put out the smoldering fires. Neither lead nor asbestos would likely be released in smoke from a fire.

*If there are any fires, would there be a potential for other contaminants to be released in the air?*

### 5.4

## TOXICOLOGICAL PROPERTIES (HAZARD IDENTIFICATION)

This section contains hazardous properties of lead.

### 5.4.1. METABOLISM

#### Asbestos: (Deposition, removal, and migration)

The physical nature with respect to the diameter and branching characteristics of the conducting channels for airflow in the respiratory system is such that fibers longer than 50 micrometers or thicker than 3 micrometers rarely penetrate to the deep, alveolated portions of the lung. Fibers of these and greater lengths and diameter do enter the nostrils or mouth but are deposited on the surface of the air conducting passages through which they pass or, along with a large proportion of the shorter and thinner fibers, they remain entrained in the air mass and exit with the expired air. Those particles deposited on the walls of the conducting airways are brought via the muco-ciliary system to the oral cavity and along with those particles entrapped in the mucous secretions on the surface of the nasal and oral pharynx are expectorated or removed in the nasal discharge or are swallowed and enter the gastro-intestinal system.

Those fibers that remain for some time in the deeper, alveolated portions of the lung have differing fates. A major portion of those fibers that are less than 10 micrometers in length are totally engulfed by macrophages which by their inherent mobility move out onto the mucous surfaces being drawn out into the air conducting tubes and ultimately are brought up to the oral cavity. Longer

fibers tend to remain in the alveolated parts of the lung where they take part in the tissue reactions leading to fibrogenesis and other sequelae. Some fibers migrate into the lymph and the bloodstream and are disseminated elsewhere in the body outside the lung proper. Other fibers move into the supporting structure of the alveolated tissues and into the cells lining these structures. There is evidence that chrysotile fibers deposited in the lung tissue undergo very slow alterations induced by the action of lung cells and fluids leading to dissolution or fragmentation of the fibers and subsequent removal via the macrophage action. In the course of their residence within the lung, single fibers of chrysotile only may split longitudinally into larger numbers of thinner fibers or fibrils. Thus, the total number of fibers resident within the lung tissue may be enhanced. These changes of fiber size and number do not occur with respect to the amphiboles. A further portion of the fibers of all types of asbestos undergo a slow coating or encapsulation, forming the so-called "asbestos body". In contrast to naked fibers, there is some evidence that such structures lose their potential for fibrogenesis.

Fibers that enter the gastro-intestinal tract via lung cleansing or food or water pass directly through and emerge in the feces. There is no evidence of penetration of the gut wall or storage in regional lymph nodes either in humans or in experimental animal feeding experiments.

### Lead

The principal source of lead for humans is via ingestion, mostly with food. Between 5-15 percent of the ingested lead is absorbed. Ingestion of lead-based paints is the most common source reported for clinical cases. Children absorb a higher proportion of ingested lead than adults do. Absorption of lead by experimental animals has been shown to vary with the fat, protein, and mineral content of the diet.

In adults, 95 percent of the lead found in the body is bound to bone tissue. Children absorb a lower percentage in the bones.

Upon entering the body most lead compounds dissociate. Metabolism is therefore not a factor. An exception is the alkyl lead compounds such as tetra-ethyl lead and tetra-methyl lead. These are dealkylated to form more toxic tri-alkyl and di-alkyl compounds.

#### 5.4.2. ACUTE TOXICITY

##### Asbestos:

There are no acute (brief lapse time after onset of exposure) clinical effects of exposure to asbestos via either the respiratory or ingestion route. Though a macrophage response occurs rather quickly to deposition of fibers by inhalation, this is a normal response to particulate in the lung and part of the defense system of the body.

##### Lead:

Acute toxicity to humans is generally not of great concern because of regulation to prevent the serious effects of exposure to significant concentrations of lead.

#### 5.4.3. CHRONIC AND SUBCHRONIC TOXICITY, CARCINOGENICITY AND MUTAGENICITY, TERATOGENICITY AND OTHER HEALTH EFFECTS

##### Asbestos

The clearly demonstrated clinical developments which may occur in response to inhalation of sufficient quantities of asbestos fiber of the known biologically pertinent sizes are (1) diffuse interstitial pulmonary fibrosis (asbestosis), (2) an excess occurrence of bronchogenic cancer, (3) an excess occurrence of pleural and peritoneal mesothelioma, (4) spontaneously reversible pleural effusion, and (5) thickening of the pleura either of a diffuse nature or as plaques with or without calcification. There is rather strong but not compelling evidence of an excess of laryngeal cancer. None of these biological effects of asbestos occurs uniquely as a result of exposure to asbestos. Each can be produced by other causes. Each of the biological responses is clearly related, to a greater or lesser degree, to the cumulative exposure level. Clearly these reactions are governed by a dose-response effect. None manifests themselves in fewer than several years after onset of exposure and some only after many years subsequent to the onset. There are examples of each of these abnormalities occurring in individuals who have had rather short but intensive exposures to asbestos fiber. The fact that each of these biological responses can develop as a result of causes other than asbestos and also in persons not exposed other than to the relatively low universal or general environmental exposure levels makes it difficult to evaluate such cases.

There is rather strong evidence suggesting that in the circumstances of human exposure, crocidolite and amosite have a greater proclivity for causing an adverse biological

*It should be specifically stated what are the harmful effects that asbestos will cause in people besides the fact that asbestos may be assumed being harmful only if an intensive exposure has been made.*



Even though crocidolite and amosite have a greater biological adverse effect, what are the critical factors evolving from chrysotile fibers?

response than does chrysotile. This might be anticipated on the basis of three known factors. First, the nature of crocidolite is such that in circumstances of its use, it is "dustier", especially with respect to re-suspension of settled dust, than is chrysotile. Thus, the exposure levels may have been meaningfully higher in the past for crocidolite. Second, the fibers of crocidolite are straight rather than curly, as is the case for chrysotile, and thus their penetration to and deposition in the deep lung regions would be enhanced at equal airborne levels. Third, both crocidolite and amosite are clearly much more durable in lung tissue than is chrysotile. Whether this plays a role in the long term effects in humans is unknown.

There are some studies that appear to show a relationship between substantial occupational exposure to asbestos and an excess occurrence of tumors in the gastro-intestinal tract. In contrast, there are more numerous other studies that do not demonstrate such an outcome. As of this point in time, a thorough review of the data by three separate, accepted knowledgeable sources indicate that the evidence at hand supports the view that there is no demonstrable causal relationship between exposure to asbestos by inhalation or ingestion and the development of an excess occurrence of gastro-intestinal tumors. There also are a number of studies bearing on this same question with respect to exposure of the general public - the ingestion of asbestos fibers in food and water supplies. The evidence in these studies strongly supports the conclusion that exposure does occur via those route, but there are no biological sequelae demonstrable.

Is this to say that the only time asbestos becomes health-hazardous related is when only an exposure and has been digested?

The above findings in humans are strongly supported by the experiments in which rodents have been fed large quantities of asbestos in their diet over all or a major portion of their life. The weight of the evidence in these extensive studies by several separate laboratories using large numbers of animals indicates that ingestion of asbestos is not carcinogenic even though the ingested fibers were of the long, thin category.

Nonoccupational exposure of persons resulting from contamination of the home by transport of fibers from the workplace to the home via persons occupationally exposed has led to some of the manifestations of asbestos-related disease in those who have not been actually occupationally exposed. The same has been observed to a lesser extent in some but not all circumstances in populations that live in the immediate neighborhood of commercial operations where asbestos fibers in the past have been cast into ambient air. The manifestation of these response to asbestos fibers has been primarily their effect on the pleura, including mesothelioma. There are no published data describing the actual exposure levels that evoked these

responses but there is reason to believe they were of the high category and their effects are not surprising in the light of current knowledge. There are a number of studies pertinent to whether populations not occupationally exposed or not subject to family or neighborhood exposure, in other words the general population, has experienced an adverse effect of the exposure to asbestos fibers in the ambient air. These studies strongly support the conclusion that there has been no effect on the general public. This is not surprising because the fibers in the air of the general public, when compared to those levels in the workplace where biological effects have occurred, are not only very low in concentration but overwhelmingly are of the short (less than 5 micrometers) size. An exception to these findings in the general public has occurred in some localities in various places in the world where amphiboles in fibrous form are present in surface soil and have been dislodged by agricultural pursuits or have been actually used in the construction of dwellings.

#### Mutagenicity and Teratogenicity:

There are no reports of mutagenic or teratogenic effects of asbestos.

#### Lead:

##### Chronic and Sub-Chronic Toxicity

Chronic and sub-chronic toxicity exposure to lead results in decreased synthesis of hemoglobin and thus decreased concentrations of hemoglobin in the blood. Synthesis of other hemo-proteins is also inhibited. Longevity of erythrocytes is reduced, probably through damage to the cell membrane. Effects of lead on the hematopoietic system occur at lower concentrations than the effects on other organs.

Chronic exposure to lead can also result in neurological dysfunction or lead encephalopathy. The incidence of severe encephalopathy is declining following recognition of the cause. Lower doses of lead produce less severe neurological effects, such as subtle differences in learning ability and other mental functions.

##### Carcinogenicity and Mutagenicity

Limited data from studies of laboratory rats suggest that lead has carcinogenic effects at a dietary concentration of 29  $\mu\text{g}$  per kg. The application of those results to humans has been questioned,<sup>3</sup> however. TLV of inorganic lead is 0.15  $\text{mg}/\text{m}^3$ . This is set to prevent systemic effects. Lead is a

suspected occupational carcinogen for kidney and liver.

There is no data reported on the mutagenic effects of lead.

#### Teratogenicity/Reproductive Effects

There is little indication of teratogenic effects of lead on humans. However, numerous studies of animals have indicated teratogenic effects. The effects were achieved by administering high doses of lead intravenously or intraperitoneally. Teratogenic effects appear unlikely from environmental exposure.

Reproductive effects of lead have been demonstrated both from occupational exposure (under conditions that no longer occur in the workplace) and experimentally in laboratory animals via ingestion of high concentrations of lead in drinking water. Some studies have indicated reproductive effects of indirect exposure. A Japanese study reported increased incidence of miscarriages among the female lead workers. Excessive exposure to lead during pregnancy has resulted in neurological disorders in infants.

The observed reproductive effects, like the other chronic effects, result from total exposure via air, water, and food. It is thus usually difficult to relate the effect to a particular route of exposure.

#### Other Health Effects

Other health effects of lead have been reported, but these are generally the results of very high exposures. These include impairment of thyroid function, and induction of intestinal colic.

### 5.4.4. AQUATIC/NON-HUMAN TERRESTRIAL SPECIES TOXICITY ENVIRONMENTAL QUALITY IMPAIRMENT

#### Asbestos:

There are no known effects of ambient asbestos fibers on fish, freshwater invertebrates, aquatic plants or non-human terrestrial species. Data presented in Appendix J, Volume II, show that asbestos fiber levels of  $10 \times 10^6$  fibers per liter are common in freshwater supplies.

#### Lead:

The toxicity of lead to freshwater organisms varies with water hardness. At hardness of 300 mg per liter, the 24-hour average concentration of lead should not exceed 50  $\mu$ g

per liter and the maximum concentration should not exceed 658  $\mu\text{g}$  per liter. Chronic effects on some freshwater invertebrate species have been observed at concentrations as low as 25  $\mu\text{g}$  per liter. Fish are affected by chronic exposure at 31  $\mu\text{g}$  per liter in soft water but can tolerate much higher concentrations in hard water. Chronic effects on fish include spinal deformities.

Effects on some aquatic plants have been observed when lead concentrations exceed 500 to 28,000  $\mu\text{g}$  per liter. Plants are therefore less susceptible than aquatic animals.

## 5.5 EXPOSURE ASSESSMENT

Exposure assessment of human and non-human population and environmental resources by asbestos and lead contaminants from the waste disposal area is presented in this section.

### Asbestos:

One pathway (route) of exposure to asbestos fibers from this site would be via inhalation. Johns-Manville Sales Corporation employees working on and around the waste disposal area and persons using recreational facilities near the disposal area could be exposed to asbestos fibers at very low levels.

Asbestos fiber concentrations at all off-site sampling locations were not measurably different from results obtained for field and laboratory blanks. Therefore, while there is a potential for exposure of residents near the site, it appears that any actual exposure would not be measurably different from background levels. This is not surprising in light of the low concentrations observed on site and expected reductions in concentrations over distance due to aerial dispersion.

Wildlife could also be exposed, especially those species which harbor in the areas to the north of the site. The probable exposure to asbestos fibers of human and non-human population is low. It is unlikely that the asbestos would threaten use of Lake Michigan by area residents for recreation and other purposes.

### Lead:

One pathway of exposure to lead can be via inhalation of fugitive dust or ingestion of contaminated soil. Additional data on lead concentration in the air is planned for detailed exposure assessment through this pathway. Children are more susceptible to lead poisoning through this exposure route than adults. The site access is restricted and there are no residential dwellings or schools within 0.50 mile radius of the site.

Another route of exposure can be through lead contaminated groundwater. The leachability of lead to the groundwater is

very low because of the alkaline nature of the wastes disposed at this site. There are no groundwater drinking supplies within 0.50 mile radius of the site and all nearby groundwater supplies are located upgradient from the direction of the groundwater movement from this site.

#### 5.6 . RISK ASSESSMENT

Site access is restricted and groundwater at the site is of drinking water quality. The off-site migration potential is low. Asbestos fiber concentrations at all off site sampling locations were not measurably different from results obtained for field and laboratory blanks suggesting that the disposal area in its current condition does not produce a measurable contribution to ambient off-site asbestos counts. Therefore, the risk to the human health and environmental resources in the vicinity of the site is minimal, if any. More over, all observed values for asbestos fibers longer than 5 microns were at or near the detection limit.

#### 5.7 CONCLUSIONS

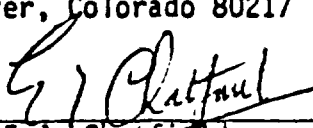
The site does not threaten the existing or future uses of Lake Michigan water, groundwater, air, and other environmental resources in the vicinity of the site.

ORF REPORT 10335

COLLECTION AND ANALYSIS OF AIR SAMPLES  
FOR THE WAUKEGAN LANDFILL AMBIENT ASBESTOS  
MONITORING STUDY  
FINAL REPORT

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20 February 1985

**RESEARCH**

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## TABLE OF CONTENTS

	<u>PAGE</u>
1. INTRODUCTION.....	1
2. AIR SAMPLING.....	1
3. SAMPLE ANALYSIS.....	4
4. RESULTS	
4.1 On-Site and Off-Site Asbestos Fiber Concentrations.....	5
4.2 Measurements of Blanks.....	7
4.3 Analytical Quality Assurance.....	7
5. CONCLUSIONS.....	8
6. REFERENCES.....	13
FIGURES	
TABLES	
APPENDIX A - ANALYTICAL QUALITY ASSURANCE	

## 1. INTRODUCTION

During October and November, 1984, an air sampling program was conducted in the vicinity of the landfill of the Johns-Manville Sales Corporation manufacturing facility at Waukegan, Illinois. Background samples were also collected at three off-site locations. The landfill had been selected by the U.S. Environmental Protection Agency as a site under CERCLA, and the purpose of the sampling was to determine if the landfill was contributing airborne asbestos fibers to the ambient air. The air sampling plan stipulated that five samples should be collected at each of five locations in the vicinity of the landfill, and that three off-site samples should be collected during each of the five on-site sampling periods.

Analysis of the samples was to be conducted by transmission electron microscopy (TEM), using the specified U.S. EPA procedure for sample preparation and fiber counting.<sup>1</sup>

## 2. AIR SAMPLING

Sampling of ambient air for the presence of asbestos fibers is performed using Nuclepore polycarbonate filters. This type of filter lends itself to direct preparation of electron microscope specimen grids. In order to obtain a detection level of about 0.003 fiber per milliliter (fiber/mL), it is necessary to filter about 10 - 12 cubic meters of air through a filter of about 10 sq. cm. active area. The program protocol specified a 12 hour sampling period, timed to coincide with the day shift at the manufacturing facility. In order to meet the detection level requirements, it was necessary to operate at flowrates as close to 15 liters/minute as possible. However, samples with too high a loading of particulate other than asbestos cannot be analyzed, and the total air volume from which the particulate is collected must be selected so as to provide a satisfactory TEM specimen for analysis. Since this requires a knowledge of the total particulate loading of



the air prior to sampling, a pre-test had been specified to establish a suitable air volume for the main study. The pre-test was to be conducted using three samplers at the same location, operating at three different flowrates (approximately 5, 10 and 15 liters/minute).

Each sampling station consisted of a Millipore stainless steel filter holder which held a 0.2 micrometer pore diameter Nuclepore polycarbonate membrane filter, backed by a 5 micrometer pore size Millipore cellulose ester filter. The support mesh of the holder has been shown to cause local restriction of airflow through the filter, and thus variations in the density of the particulate deposit result in errors when the filter is sub-sampled for preparation of the TEM grids. Therefore, a backing filter is used to ensure that the supporting mesh does not cause non-uniformity of the collected deposit on the Nuclepore filter. The sampling pump was Millipore Catalogue No. XX60 000 00, and the power was supplied by a portable gasoline-driven generator. For the 15 liters/minute flowrate, the maximum capacity of the pump was used, and the flowrates of 10 and 5 liters per minute were obtained by restricting the flow using critical orifices. The pump-filter systems were individually calibrated at the Ontario Research Foundation laboratory, both before and after the sampling program. (No corrections were made for ambient temperature and pressure effects on the flowrate, since these were small compared with the other measurement errors.) *no temp reported*

The use of 0.2 micrometer pore diameter filters was dictated by the unavailability of 0.4 micrometer pore diameter filters which are not contaminated by unacceptable levels of asbestos fibers. This lot number of 0.2 micrometer pore size filters was known to be acceptably low in fiber contamination. The smaller pore diameter just permits the required flowrates to be obtained.

Wind speed and direction data were obtained by using a recording instrument installed on the top of the roofing products building on the west side of the site. The on-site sampling stations were selected to provide coverage of all wind directions, and were located as shown in Figure 1. Figures 2 - 7 show sampling equipment in position for the pre-test.

2, ← and at the five on-site locations. At location 2, two samplers were operated, one containing the Nuclepore filter for the program, and the other a Millipore filter which could be sampled at a higher flowrate. The Millipore filter was intended for any optical microscopy which might be necessary for interpretation of the data. However, the sample analyses were straightforward and the Millipore filters were not used. All of the sampling heads (filter holders) were held at a height of about 5 feet from the surface, to simulate the breathing height of an adult.

The pre-test was attempted on Thursday, October 18th at a site on the north end of the landfill. Shortly after sampling was initiated, it began to rain, and the test was terminated. Since the program protocol called for 24 hours without precipitation prior to commencing air sampling, the program was delayed until the following week. The pre-test was successfully conducted on October 22nd.

It was considered that the dust levels were sufficiently low to warrant proceeding to the actual sampling runs without waiting for analysis of the pre-test samples. In practice, when ambient air is being sampled an experienced analyst can judge from the appearance of a Nuclepore filter whether it is suitably loaded for TEM analysis. In view of the constraints of weather conditions, and the approaching winter, with the agreement of the U.S. EPA representative, Mr. W. Maines, it was decided to continue sampling runs so long as the weather permitted. All of the sampling runs were conducted within the constraints of meteorological conditions specified by the U.S. EPA protocol. During the five sampling periods all wind directions were represented, and ground conditions ranged from wet to relatively dry. Run 2, for example, on 24 October 1984, was started when there had been no precipitation for 3 days. The pre-test filters were examined on site, and it was considered that the highest flowrate filter could be analyzed satisfactorily. Accordingly, the pumps were operated at their maximum calibrated flowrates, in order to achieve the lowest detection limits possible. Under these circumstances, the only function of the

pre-test would be to indicate if samples collected at the highest flowrate were too heavily loaded with particulate for them to be analyzed satisfactorily. Later inspection of TEM specimens prepared from the pre-test samples confirmed that samples collected at the highest flowrate were suitable for analysis, and the whole sampling program was conducted using the highest flowrate available.

The off-site locations were selected to be remote from the landfill and on the property of Johns-Manville Sales Corporation employees so that interference with the samplers by members of the public could be avoided. Figure 8 shows the locations of the three off-site samplers.

The air sampling data are shown in Tables 1 to 5 for the five sampling runs. Figures 9 - 13 show the wind speed and direction charts for the sampling periods, and a summary of the wind speed and direction for each sampling period is given in Table 6.

### 3. SAMPLE ANALYSIS

The filters were all hand-carried to the Ontario Research Foundation laboratory, and were prepared according to the U.S. EPA analytical method for determination of asbestos in ambient air.<sup>1</sup> In this method, a portion of the filter is carbon-coated in a vacuum evaporator, after which a 3 mm square piece of the coated filter is placed on a copper support grid and solvent-extracted using chloroform in a Jaffe washer. The grid is examined in the TEM, and all fibers are identified and measured, continuing the examination until 20 grid openings have been scanned or 100 asbestos fibers have been detected. Fibers are classified as chrysotile, amphibole, or other fibers. Since there is usually interest in the fibers longer than 5 micrometers, if 100 or more asbestos fibers are detected before examination of 20 grid openings has been completed, the examination is continued to 20 grid openings, recording only the fibers longer than 5 micrometers. In

*aren't fibers  $\leq 5$  mm a threat to human health as the ones  $\geq 5$  mm are?* ✓

another situation, when 100 or more chrysotile fibers have been found before 20 grid openings have been examined, the examination is continued, but recording only the amphibole fibers. (This procedure is necessary if the best statistical validity is to be achieved for measurement of both chrysotile and amphibole fibers.)

*By the preceding sentence says only amphibole fibers are recorded, how is the best statistical validity achieved for both chrysotile and amphibole fibers?*

#### 4. RESULTS

##### 4.1 On-Site and Off-Site Asbestos Fiber Concentrations

Tables 7 to 11 give summaries of the number of asbestos structures counted during examination of the filters from the 5 sampling runs at the 5 on-site and 3 off-site locations. These data show the relative proportions of single fibers, fiber bundles, fiber matrices and fiber clusters observed in each sample. These values are reported for chrysotile and amphibole structures of all lengths. In accordance with the EPA analytical method, matrices and clusters are not included in the reported fiber concentrations.

*Lengths  $\leq 5 \mu m$  were not reported*

*Contrast*

The precision of asbestos fiber counts is controlled by the number of fibers counted and by the degree to which the fibers are distributed uniformly on the collection filter. Although every effort is made to ensure uniformity of the sample, the character of the suspended fibrous aerosol often determines the uniformity, in particular the degree of aggregation. For a fiber count of about 100 fibers, under the best conditions a precision of  $\pm 50\%$  can be expected, and where the fibrous component of the deposit is not uniformly distributed on the filter some very wide confidence intervals can be obtained. Where less than 5 fibers are reported in any category, the mean value for the concentration cannot be specified because it is statistically not significant (NSS).<sup>2</sup> Where no fibers were detected in a category, the result is specified as "none detected" (ND). However, in both cases it is possible to

specify the upper 95% confidence limit, which represents the realistic maximum concentration indicated by the measurement. The fiber concentration values reported include individual fibers and fiber bundles.

During the analysis it was found that there were substantial numbers of gypsum fibers on the samples. These were present in generally much larger numbers than the asbestos fibers. A few man-made mineral fibers were also present on many of the samples.

The results of the fiber counting for the first sampling run (23 October 1984) are shown in Tables 12 and 13. As can be seen in these two tables, for asbestos fibers plus fiber bundles of all lengths, the maximum mean concentration found was 0.021 fiber/mL, and for asbestos fibers longer than 5 micrometers, the maximum mean concentration found was 0.003 fiber/mL. Where the number of fibers found was too low to report a mean concentration, the maximum upper 95% confidence limit was 0.006 fiber/mL, both for fibers of all lengths and for those longer than 5 micrometers.

Tables 14 and 15 show the results for the second sampling day (24 October 1984). In this case, a sampler malfunction invalidated one of the off-site samples, and consequently there are only 2 off-site results. It can be seen that the results are generally similar to those of the first run, although they are somewhat higher. Nevertheless, the mean values for those fibers and fiber bundles longer than 5 micrometers were no higher than 0.006 fiber/mL.

The third sampling run was conducted on 29 October 1984, and the results are shown in Tables 16 and 17. None of the mean asbestos fiber concentrations obtained exceeded 0.006 fiber/mL.

The fourth sampling run was conducted on 30 October 1984, and the results are shown in Tables 18 and 19. None of the mean asbestos fiber concentrations exceeded 0.008 fiber/mL.

The fifth sampling run was conducted on 05 November 1984, and the results are shown in Tables 20 and 21. The highest concentrations of asbestos fibers observed during this run were values of 0.039 fiber/mL and 0.027 fiber/mL, measured at locations 2 and 5 respectively. However, at these locations the mean concentrations of fibers longer than 5 micrometers did not exceed 0.004 fiber/mL.

#### 4.2 Measurements of Blanks

Both field and laboratory blanks were analyzed in accordance with the specified protocol. The results of these analyses are shown in Table 22. An air volume of 10m<sup>3</sup> was assumed in order to refer the blank values approximately to the actual measurements.

#### 4.3 Analytical Quality Assurance

Three duplicate samples (TEM specimen grids counted by a second operator) were analyzed. Replicate sets of TEM specimen grids were prepared from different areas of three selected filters. These were analyzed by the primary TEM operator at ORF. In addition, a second laboratory prepared TEM specimen grids from portions of three selected filters and a blank filter and analyzed these to provide an inter-laboratory check on the results. EMS Laboratories, Hawthorne, California, was selected as the external laboratory for this work.

All of the analytical quality assurance work was statistically compatible and is discussed in more detail in Appendix A.

## 5. CONCLUSIONS

The results indicate that the mean fiber concentrations were of the order of a few fibers per liter of air, except for isolated values for chrysotile only in Runs 1, 2 and 5 ranging between 0.020 fiber/mL and 0.065 fiber/mL. The maximum values found in each Run have been summarized in Table 23. It can be seen that in Runs 3 and 4, the maximum values observed are not measurably different from the values obtained for the field and laboratory blanks. As can be seen from the off-site measurements in Tables 13, 15, 17, 19 and 21, none of the values was measurably different from the results obtained for field and laboratory blanks. Most jurisdictions which have established control limits or "guidelines" for asbestos fibers in ambient air have done so on the basis of those fibers longer than 5 micrometers.<sup>3</sup> The measurements of fibers longer than 5 micrometers at the Waukegan landfill were only rarely statistically significant, and the maximum mean value found was 0.006 fiber/mL.

Since most of the fiber concentrations were below the level of statistical significance, average fiber concentration values for the whole site can only be calculated from the upper 95% confidence limits. These upper confidence limits represent the concentrations which would only be exceeded for 2.5% of repeat measurements. The upper 95% confidence limits of the fiber concentrations have been averaged for each sampling run, and these are shown in Table 24. The corresponding averages for the whole study, including all five sampling runs, are shown in Table 25. The fiber concentrations shown in Table 25 represent average values which would be exceeded in only 2.5% of repeat measurements, for the range of weather conditions experienced during the study. For chrysotile, this on-site average value was statistically higher than that for the off-site samples, both for fibers of all lengths and for those fibers longer than 5 micrometers. However, for fibers of all lengths, the on-site value of 0.022 fiber/mL is only a factor of 4.5 higher than the off-site

value of 0.0049 fiber/mL, which is itself at the detection limit, bearing in mind the low, but detectable, level of contamination on the blank filters. For chrysotile fibers longer than 5 micrometers, the on-site value of 0.0046 fiber/mL is elevated by only 64% over the minimum detection level of 0.0028 fiber/mL found in the off-site locations. The average upper 95% confidence limit of amphibole fiber concentration was at the detection limit of the measurement, both for fibers of all lengths and for fibers longer than 5 micrometers.

The highly aggregated nature of the suspended particulate leads to some limitations in the statistical interpretation of the values. It has been accepted in the analytical method for asbestos fibers in water<sup>2</sup> that a test for uniformity of the fiber deposit on the filter should be made before the fiber count can be considered to be valid. This test requires that a chi-square analysis be made of the individual grid opening fiber counts, and that this test be passed at better than 0.1% significance. In the method for water, if this test cannot be passed, the sample is rejected and re-prepared. Table 26 shows the chi-square analyses for all of the samples in this survey. When results are very low, corresponding to detection of only a few fibers in the area of sample examined, the test is passed satisfactorily at significance levels exceeding 0.1%. In practically all of the samples which displayed statistically significant numbers of fibers, however, the uniformity criterion could not be passed. This problem can only be overcome by analyzing the samples using the indirect method of specimen preparation, involving ashing of the collection filter and re-dispersal of the deposits in water.<sup>4</sup> This is not the EPA method of choice, because of concern that the nature of the sample will be modified by the analytical procedure. The problem has not yet been addressed properly in the context of unsatisfactory performance by the direct method, but it is a problem which requires resolution. Work by the members of the International Organization for Standardization working group ISO/TC146/SC3/WG1<sup>5</sup> is directed towards this difficulty and, as more data become available on the characteristics of the analytical methods when applied to real situations such as this study,



it is hoped that an internationally-agreed solution to the problem will be found. For the results of this survey, however, it will have to be accepted that the nature of the fiber deposit on the collection filter seriously compromises the validity of any statistically significant result.

In order to place the results of this survey in the context of measurements made elsewhere, it is useful to examine the guidelines established by various jurisdictions for asbestos fiber concentrations in ambient air. These have been discussed by Chatfield,<sup>3</sup> and are presented in Table 27.

( The West German proposal to limit ambient asbestos fiber concentrations to less than 1 fiber/liter (fibers longer than 5 micrometers) is considered to be an objective.) The measured fiber concentrations in Germany exceed this value, and are usually a few fibers per liter, as they are elsewhere.<sup>6</sup> In fact, using currently available direct analytical methods, the high total suspended particulate concentrations in urban environments would preclude measurement of concentrations less than 1 fiber/liter. In the Waukegan study, the samples were sufficiently loaded with particulate material other than asbestos that it would not have been possible to analyze samples from a substantially greater volume of air. The detection limit is simply a function of the volume of air per unit area of the collection filter and the area of the final TEM specimen which is examined, in this case 20 grid openings of about 85 micrometer size. Using the direct analytical method, the only way to improve the detection limit is either to increase the air volume collected or to increase the number of grid openings counted. It is clearly impractical to greatly increase the number of grid openings counted, and if the filter is already loaded with particulate to the maximum extent, the detection limit is defined. During sampling at the Waukegan landfill and at the off-site locations, the analytical sensitivity of 0.0007 fiber/mL was the best that could be obtained, leading to a detection limit of 0.003 fiber/mL (the upper

95% confidence limit for a fiber count of zero, assuming fibers to be distributed according to a Poisson relationship). This assumes that blank filters yield a fiber count of zero, which is not usually the case. If the blank filters yield a fiber count of 7 when 20 grid openings are examined, which seems to be a realistic assumption, the upper 95% confidence limit (14.4 fibers) corresponds to a fiber concentration of 0.01 fiber/mL, and the detection limit is of this order. It is rare to find fibers longer than 5 micrometers as background contamination of unused filters. Therefore, if only fibers longer than 5 micrometers are considered, the detection limit is usually close to that obtained assuming zero background. The actual fiber concentrations found, therefore, must be interpreted in terms of the probable detection levels.

Some of the on-site measurements were found to be above the detection limit of the analyses, the maximum being 0.065 fiber/mL. Bearing in mind the extreme non-uniformity of this sample, and the consequent wide 95% confidence interval (0 - 0.15 fiber/mL), this maximum value is not inconsistent with measurements made in some other locations remote from known industrial sources of asbestos. Values of 0.045 fiber/mL were reported in some locations in Southern Ontario.<sup>3</sup> Fiber concentrations of this magnitude were also found in Montgomery County, Maryland, in 1977 and 1978, associated with the use of serpentinite rock for surfacing of roads.<sup>7</sup> In 1981, fiber concentrations significantly higher than those found in the measurements at the Waukegan landfill were reported near two serpentinite quarries and in the vicinity of unpaved roads constructed from such material.<sup>8</sup> It was concluded that fiber concentrations up to 2.52 fibers/mL were observed downwind of such unpaved roads. This value of 2.52 fibers/mL is much higher than those obtained in the Waukegan landfill study. Lanting and den Boeft<sup>9</sup> have reported values in large industrial towns up to 0.01 fiber/mL. Values of 0.0002 fiber/mL to 0.011 fiber/mL upwind of an asbestos plant have been reported in some studies in California.<sup>10</sup>

Although in early work on asbestos fiber concentrations in ambient air the results were reported in terms of mass concentration, such measurements are not easily used in risk estimation because of the large effect of a few thick fibers on the measurement. The works of Pott<sup>11</sup> and of Stanton and Layard<sup>12</sup> indicate that the long thin fibers are those of most concern from a health standpoint, and the mass measurement can therefore be misleading. Often, the numerical concentration values and the mass values do not correspond with each other, and opposing interpretations can be made depending on which type of data is used.

The overall conclusion which can be drawn from the results is that the majority of the asbestos fiber concentrations were close to the detection limit of the measurement method, but that for chrysotile fibers a few values were clearly higher. However, these higher values were of the same order as those observed in other locations not necessarily related to industrial use of asbestos. If only fibers longer than 5 micrometers are used as the basis of the interpretation, all the values were either at the detection limit or very close to it.

6. REFERENCES

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FIGURES





Figure 2. Air Sampling Assembly used for Pre-test.



Figure 3. Air Sampling Assembly, Location 1.



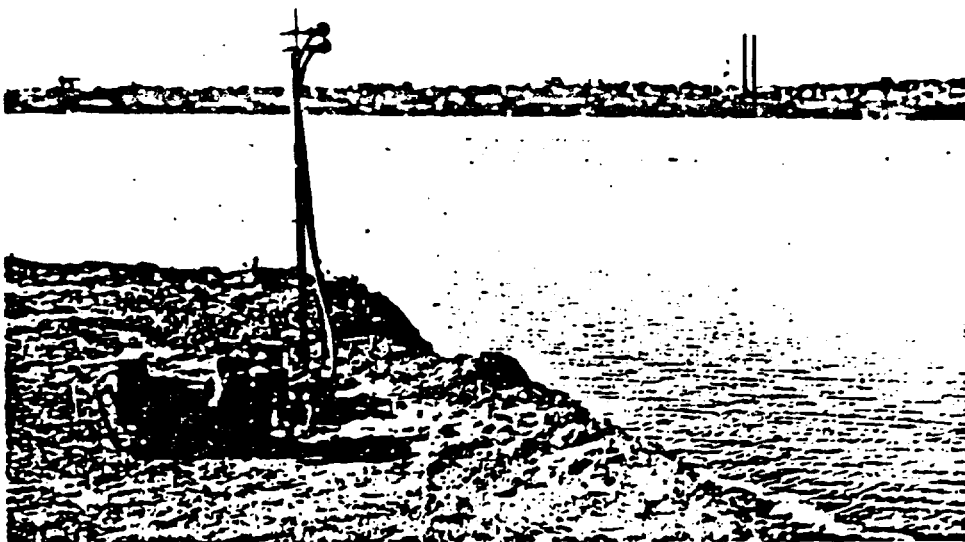


Figure 4. Air Sampling Assembly, Location 2.



Figure 5. Air Sampling Assembly, Location 3.

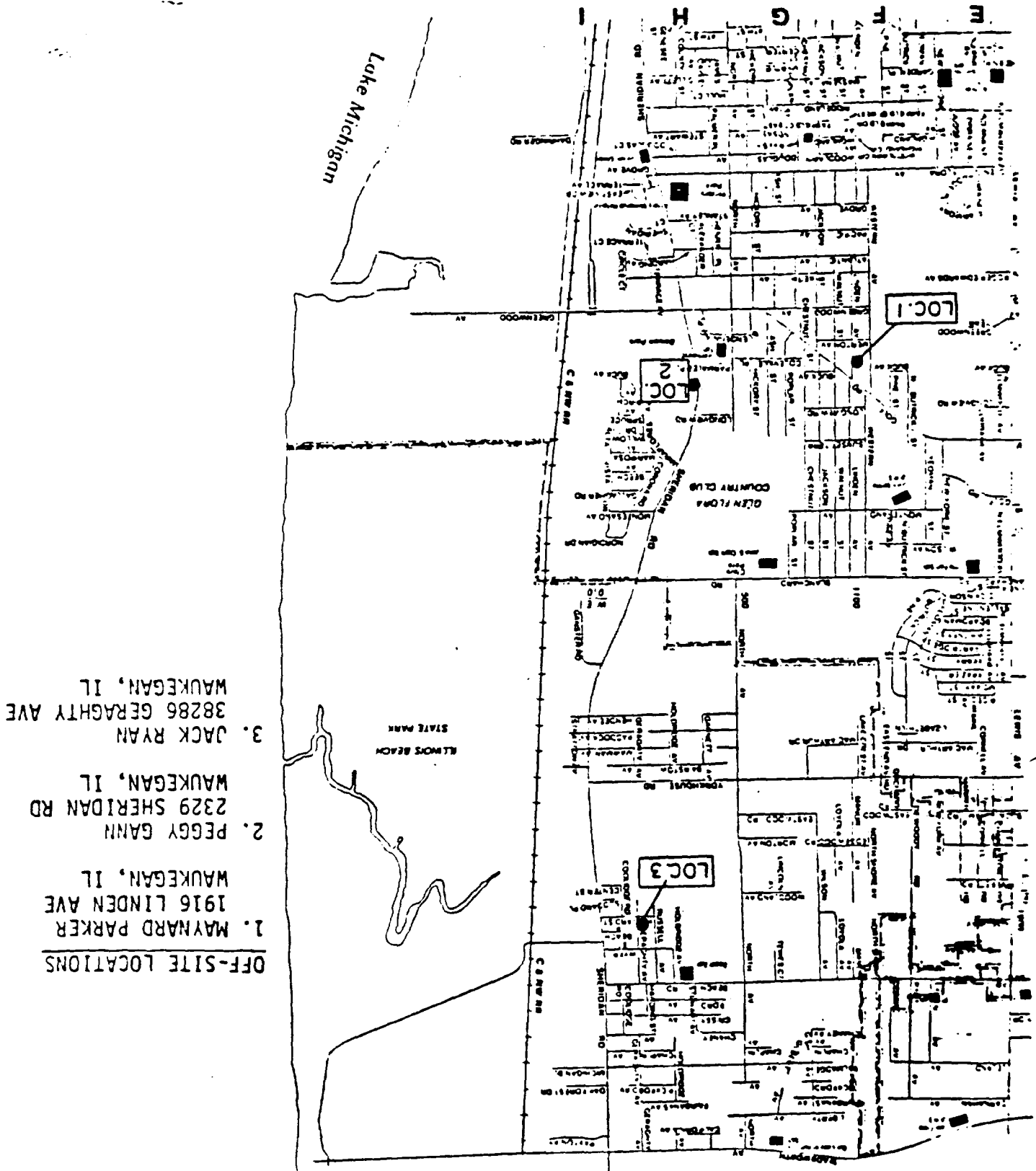


Figure 6. Air Sampling Assembly, Location 4.



Figure 7. Air Sampling Assembly, Location 5.

Figure 8. Locations of Off-Site Samplers.



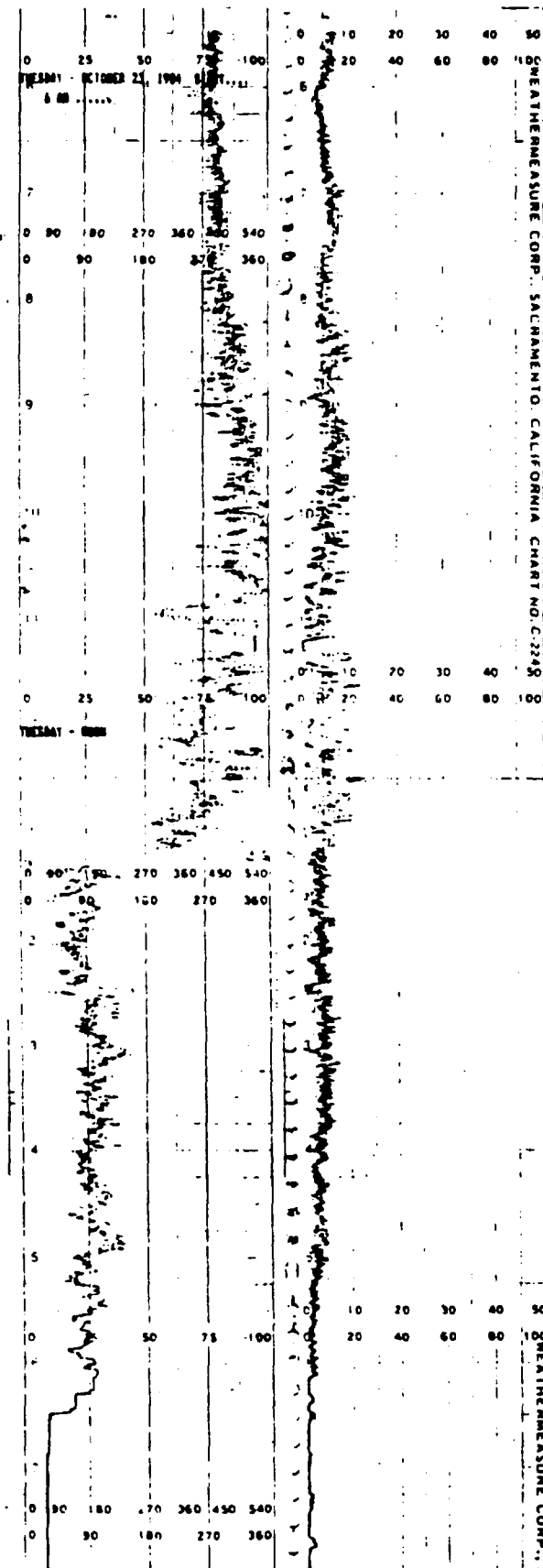


Figure 9. Wind Speed and Direction Record for Sampling Run 1 (23 October 1984).



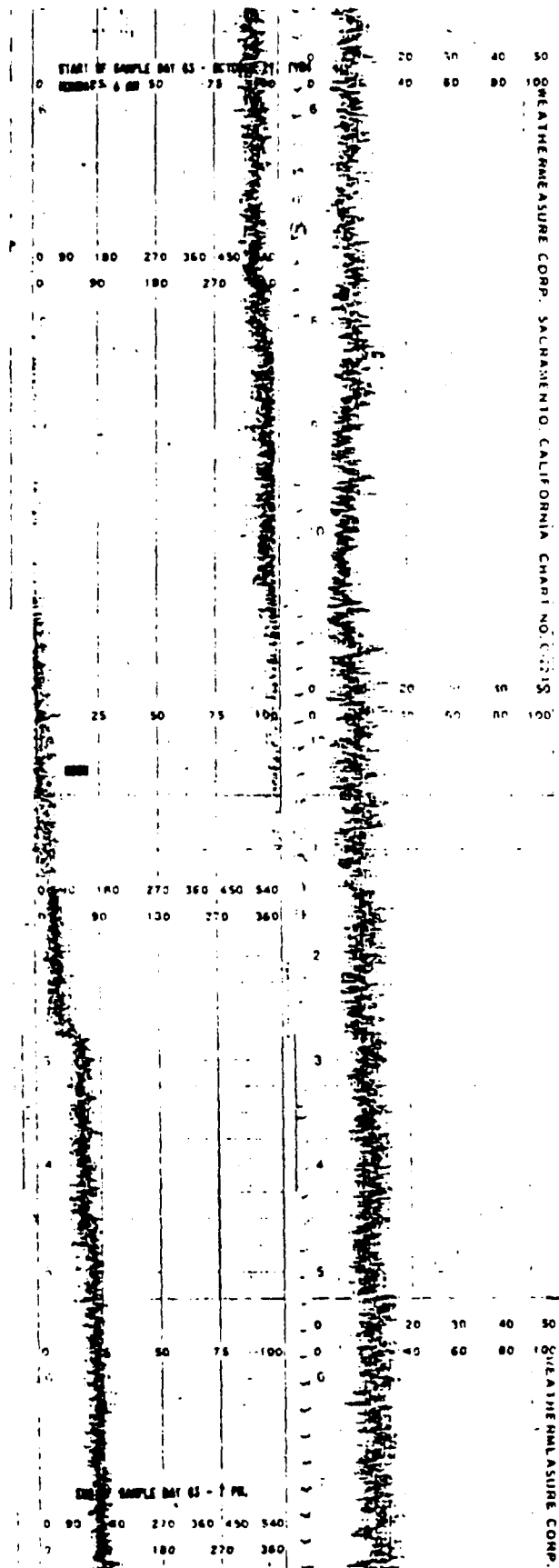


Figure 11. Wind Speed and Direction Record for Sampling Run 3 (29 October 1984).



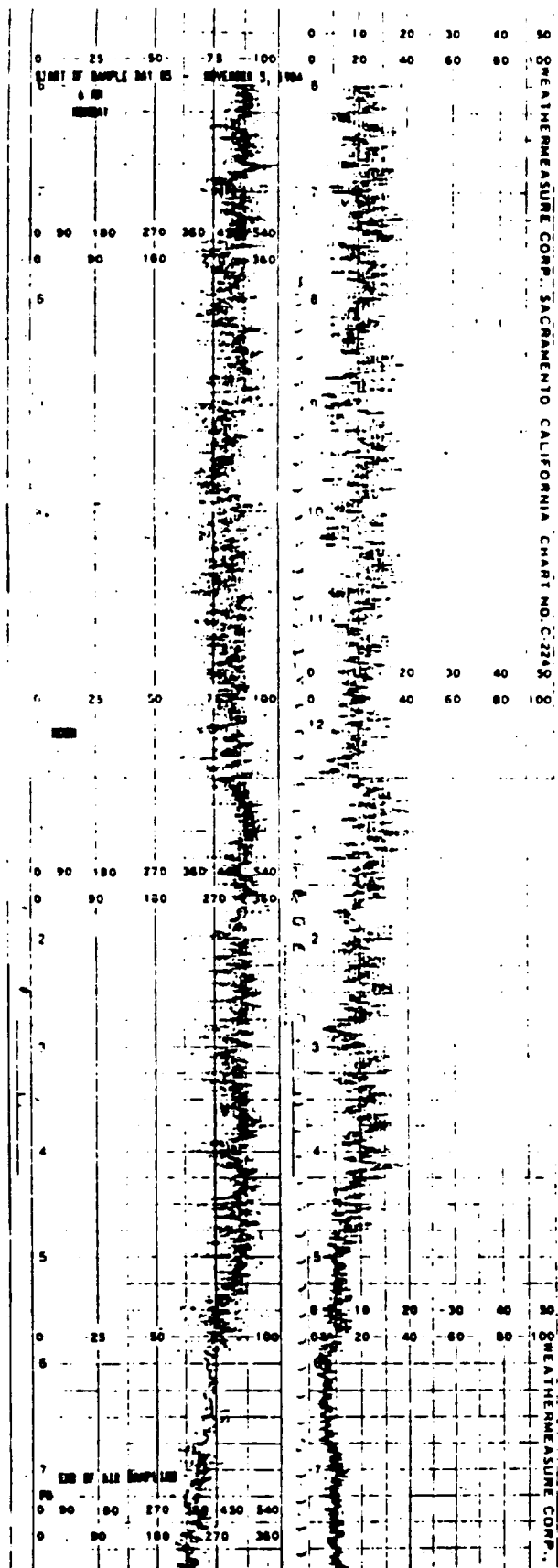


Figure 13. Wind Speed and Direction Record for Sampling Run 5 (05 November 1984).



TABLES

TABLE 1

AIR SAMPLING DATAWAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORINGRUN 1 - 23 OCTOBER 1984

SAMPLE	SAMPLING TIMES		FLOWRATE CALIBRATION (liters/minute)		AIR VOLUME SAMPLED* (m <sup>3</sup> )
	Start	Stop			
			Initial	Final	
<u>ON - SITE</u>					
Location 1	6:58	19:11	16.37	15.74	11.77
Location 2	7:14	19:21	14.60	15.94	11.10
Location 3	7:19	19:22	16.26	15.53	11.49
Location 4	7:24	19:19	14.60	15.53	10.77
Location 5	7:07	19:02	14.78	15.15	10.70
<u>OFF - SITE</u>					
Location 1	6:15	20:15	15.15	15.15	12.73
Location 2	7:00	18:55	16.16	15.94	11.48
Location 3	6:50	20:47	13.85	13.62	11.50

\* Mean of initial and final flowrates used to calculate air volumes.

TABLE 3

AIR SAMPLING DATAWAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORINGRUN 3 - 29 OCTOBER 1984

SAMPLE	SAMPLING TIMES		FLOWRATE CALIBRATION (liters/minute)		AIR VOLUME SAMPLED* (m <sup>3</sup> )
	Start	Stop			
			Initial	Final	
<u>ON - SITE</u>					
Location 1	6:44	19:07	16.37	15.74	11.93
Location 2	6:49	19:12	14.60	15.94	11.35
Location 3	6:52	19:22	16.26	15.53	11.92
Location 4	6:59	19:27	14.60	15.53	11.27
Location 5	6:39	19:00	14.78	15.15	11.09
<u>OFF - SITE</u>					
Location 1	6:03	18:27	15.15	15.15	11.27
Location 2	9:58	20:05	16.16	15.94	9.74
Location 3	6:53	20:20	13.85	13.62	11.08

\* Mean of initial and final flowrates used to calculate air volumes.

TABLE 4

AIR SAMPLING DATAWAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORINGRUN 4 - 30 OCTOBER 1984

SAMPLE	SAMPLING TIMES		FLOWRATE CALIBRATION (liters/minute)		AIR VOLUME SAMPLED* (m <sup>3</sup> )
	Start	Stop			
			Initial	Final	
<u>ON - SITE</u>					
Location 1	6:33	18:53	16.37	15.74	11.88
Location 2	6:36	18:57	14.60	15.94	11.32
Location 3	6:42	19:04	16.26	15.53	11.79
Location 4	6:48	19:07	14.60	15.53	11.13
Location 5	7:00	19:15	14.78	15.15	11.00
<u>OFF - SITE</u>					
Location 1	5:30	18:30	15.15	15.15	11.82
Location 2	7:00	19:00	16.16	15.94	11.56
Location 3	7:30	20:10	13.85	13.62	10.44

\* Mean of initial and final flowrates used to calculate air volumes.

TABLE 5

AIR SAMPLING DATAWAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORINGRUN 5 - 05 NOVEMBER 1984

SAMPLE	SAMPLING TIMES		FLOWRATE CALIBRATION (liters/minute)		AIR VOLUME SAMPLED* (m <sup>3</sup> )
	Start	Stop	Initial	Final	
<u>ON - SITE</u>					
Location 1	6:36	19:41	16.37	15.74	12.60
Location 2	6:33	19:48	14.60	15.94	12.14
Location 3	6:25	19:21	16.26	15.53	12.33
Location 4	6:27	19:27	14.60	15.53	11.75
Location 5	8:35 <sup>+</sup>	19:34	14.78	15.15	9.86
<u>OFF - SITE</u>					
Location 1	5:30	18:19	15.15	15.15	11.65
Location 2	7:00	19:00	16.16	15.94	11.56
Location 3	6:45	18:45	13.85	13.62	9.89

\* Mean of initial and final flowrates used to calculate air volumes.

<sup>+</sup> Late start because of problems with the power generator.

TABLE 6  
WIND SPEED AND DIRECTION SUMMARY

SAMPLING RUN	DATE	TIMES OF SAMPLING*	WIND SPEED	WIND DIRECTION
1	10/23/84	877 min.	6 a.m. 5 mph; varying between 0 and 10 mph at noon; decreasing to 0 mph at 6 p.m.	6 a.m. out of W; shifting to NW at noon; shifting to E from 2 - 6 p.m.
2	10/24/84	811 min.	6 a.m. <5 mph; gradually increasing to vary between 0 and 10 mph during the middle of the day; varying between 5 and 10 mph after 2 p.m.	6 a.m. out of SW; shifting to SE at 2 p.m. then to SSE from 5:30 - 7 p.m.
3	10/29/84	857 min.	6 a.m. varying between 5 and 15 mph; remaining at similar speeds throughout the sampling period.	6 a.m. out of N; at noon gradually shifting to NE; at 6 p.m. shifting to E.
4	10/30/84	880 min.	6 a.m. varying between 5 and 20 mph; dropping to about 5 mph at noon; then increasing to vary between 10 and 20 mph from 3 p.m. to 7 p.m.	6 a.m. out of SSE; slowly shifting to S after 1 p.m.
5	11/05/84	858 min.	6 a.m. varying between 5 and 15 mph; staying the same until 5 p.m.; then dropping to an average of 5 mph between 5 and 7 p.m.	6 a.m. out of NW; after 5:30 p.m. shifting to SW.

\* From first pump switched on to last pump switched off.

TABLE 7

SUMMARY OF NUMBER OF ASBESTOS STRUCTURES COUNTED  
(Structures of all lengths; 20 grid openings examined)

WAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING

RUN 1 - 23 OCTOBER 1984

SAMPLE	CHRYSTILE				AMPHIBOLE			
	Fibers	Bundles	Matrices	Clusters	Fibers	Bundles	Matrices	Clusters
<u>ON - SITE</u>								
Location 1	23	12	16	1	1	1	-	-
Location 2	3	-	1	-	-	-	-	-
Location 3	3	-	-	-	2	-	-	-
Location 4	23	7	6	-	2	-	1	-
Location 5	4	1	5	-	2	-	-	-
<u>OFF - SITE</u>								
Location 1	6	1	-	-	3	-	-	-
Location 2	1	-	1	-	-	-	-	-
Location 3	-	-	-	-	2	-	-	-

TABLE 8

SUMMARY OF NUMBER OF ASBESTOS STRUCTURES COUNTED  
(Structures of all lengths; 20 grid openings examined)

WAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING

RUN 2 - 24 OCTOBER 1984

SAMPLE	CHRYSTILE				AMPHIBOLE			
	Fibers	Bundles	Matrices	Clusters	Fibers	Bundles	Matrices	Clusters
<u>ON - SITE</u>								
Location 1*	73	12	18	3	3	-	-	-
Location 2	6	4	5	-	2	-	-	-
Location 3	5	3	4	-	-	-	-	-
Location 4	8	7	31	-	2	-	-	-
Location 5	22	9	8	-	1	-	-	-
<u>OFF - SITE</u>								
Location 1		S A M P L E			N O T A V A I L A B L E			
Location 2	2	-	4	-	2	-	-	-
Location 3	-	-	-	-	1	-	-	-

\* 16 grid openings examined for chrysotile.  
(20 grid openings examined for amphibole)



TABLE 9

SUMMARY OF NUMBER OF ASBESTOS STRUCTURES COUNTED  
(Structures of all lengths; 20 grid openings examined)

WAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING

RUN 3 - 29 OCTOBER 1984

SAMPLE	CHRYSTILE				AMPHIBOLE			
	Fibers	Bundles	Matrices	Clusters	Fibers	Bundles	Matrices	Clusters
<u>ON - SITE</u>								
Location 1	8	3	7	-	1	-	-	-
Location 2	3	3	1	-	2	-	-	-
Location 3	3	2	1	-	4	-	-	-
Location 4	4	3	6	-	3	-	-	-
Location 5	10	-	1	-	3	-	-	-
<u>OFF - SITE</u>								
Location 1	-	2	-	-	4	-	-	-
Location 2	4	1	1	-	4	-	-	-
Location 3	3	-	-	-	4	-	-	-

TABLE 10

SUMMARY OF NUMBER OF ASBESTOS STRUCTURES COUNTED  
 (Structures of all lengths; 20 grid openings examined)

WAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING

RUN 4 - 30 OCTOBER 1984

SAMPLE	CHRYSTILE				AMPHIBOLE			
	Fibers	Bundles	Matrices	Clusters	Fibers	Bundles	Matrices	Clusters
<u>ON - SITE</u>								
Location 1	4	1	9	1	-	-	-	-
Location 2	1	-	-	-	-	-	-	-
Location 3	2	-	5	-	2	-	-	-
Location 4	7	2	9	-	-	-	-	-
Location 5	11	3	22	-	6	-	-	-
<u>OFF - SITE</u>								
Location 1	3	-	-	-	1	-	-	-
Location 2	2	1	-	-	2	-	-	-
Location 3	1	1	-	-	2	-	-	-

TABLE 11

SUMMARY OF NUMBER OF ASBESTOS STRUCTURES COUNTED  
 (Structures of all lengths; 20 grid openings examined)

WAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING

RUN 5 - 05 NOVEMBER 1984

SAMPLE	CHRYSTILE				AMPHIBOLE			
	Fibers	Bundles	Matrices	Clusters	Fibers	Bundles	Matrices	Clusters
<u>ON - SITE</u>								
Location 1	14	2	10	-	3	-	1	-
Location 2	59	14	88	-	7	-	1	-
Location 3	5	5	20	-	4	-	-	-
Location 4	5	3	3	-	2	-	-	-
Location 5	29	11	47	-	6	-	1	-
<u>OFF - SITE</u>								
Location 1	1	-	-	-	4	-	-	-
Location 2	1	-	-	-	3	-	-	-
Location 3	1	-	-	-	4	-	-	-

TABLE 12 SUMMARY OF RESULTS OF ANALYSES FOR ASBESTOS

WAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING

RUN 1 - 23 OCTOBER 1984

Job Number 84487

Sample Description	FIBERS OF ALL LENGTHS					FIBERS GREATER THAN 5.0 MICROMETERS IN LENGTH					Fiber Type
	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	
	Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			
<u>ON-SITE SAMPLES</u>											
Location 1	0.021	0.005 - 0.036	0.000589	14	35	0.003	0.0009 - 0.007	0.000589	13	5	CT
	NSS	0 - 0.005	0.000589	29	2	NSS	0 - 0.004	0.000589	29	1	AT
Location 2	NSS	0 - 0.006	0.000652	0.01	3	ND	0 - 0.003	0.000652	-	0	CT
	ND	0 - 0.003	0.000652	-	0	ND	0 - 0.003	0.000652	-	0	AT
Location 3	NSS	0 - 0.006	0.000634	0.01	3	ND	0 - 0.003	0.000634	-	0	CT
	NSS	0 - 0.005	0.000634	0.06	2	ND	0 - 0.003	0.000634	-	0	AT
Location 4	0.020	0.013 - 0.029	0.000673	0.7	30	NSS	0 - 0.006	0.000673	0.3	3	CT
	NSS	0 - 0.005	0.000673	36	2	NSS	0 - 0.004	0.000673	33	1	AT
Location 5	0.003	0.001 - 0.008	0.000660	0.02	5	ND	0 - 0.003	0.000660	-	0	CT
	NSS	0 - 0.005	0.000660	0.2	2	ND	0 - 0.003	0.000660	-	0	AT

\*\* No mean value is reported when fewer than 5 fibers were detected in the portion of sample examined.

ND = No Fibers Detected

NSS = Not Statistically Significant (1 to 4 fibers detected)

\*CT = Total Chrysotile Fibers plus Bundles

\*AT = Total Amphibole Fibers plus Bundles

\*NAM = Non-Asbestos Mineral Fibers plus Bundles

\*MM = Man-Made Mineral Fibers plus Bundles

**TABLE 13 SUMMARY OF RESULTS OF ANALYSES FOR ASBESTOS**

**HAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING**

**RUN 1 - 23 OCTOBER 1984**

Job Number 84487

Sample Description	FIBERS OF ALL LENGTHS					FIBERS GREATER THAN 5.0 MICROMETERS IN LENGTH					Fiber Type
	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	
	Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			
<u>OFF-SITE SAMPLES</u>											
Location 1	0.004	0.001 - 0.008	0.000532	0.02	7	ND	0 - 0.002	0.000532	-	0	CT
	NSS	0 - 0.005	0.000532	0.2	3	ND	0 - 0.002	0.000532	-	0	AT
Location 2	NSS	0 - 0.004	0.000603	0.002	1	ND	0 - 0.003	0.000603	-	0	CT
	ND	0 - 0.003	0.000603	-	0	ND	0 - 0.003	0.000603	-	0	AT
Location 3	ND	0 - 0.003	0.000610	-	0	ND	0 - 0.003	0.000610	-	0	CT
	NSS	0 - 0.005	0.000610	0.02	2	ND	0 - 0.003	0.000610	-	0	AT

\*\* No mean value is reported when fewer than 5 fibers were detected in the portion of sample examined.

ND = No Fibers Detected

NSS = Not Statistically Significant (1 to 4 fibers detected)

\*CT = Total Chrysotile Fibers plus Bundles

\*AT = Total Amphibole Fibers plus Bundles

\*NAM = Non-Asbestos Mineral Fibers plus Bundles

\*MMH = Man-Made Mineral Fibers plus Bundles

TABLE 14 SUMMARY OF RESULTS OF ANALYSES FOR ASBESTOS

HAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING

RUN 2 - 24 OCTOBER 1984

Job Number 84487

Sample Description	FIBERS OF ALL LENGTHS					FIBERS GREATER THAN 5.0 MICROMETERS IN LENGTH					Fiber Type *
	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	
	Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			
<u>ON-SITE SAMPLES</u>											
Location 1	0.065	0 - 0.15	0.000759	88	85	NSS	0 - 0.006	0.000620	66	3	CT
	NSS	0 - 0.006	0.000620	3.3	3	NSS	0 - 0.006	0.000620	3.3	3	AT
Location 2	0.006	0.003 - 0.012	0.000633	5.3	10	NSS	0 - 0.005	0.000633	5.1	2	CT
	NSS	0 - 0.005	0.000633	0.5	2	ND	0 - 0.003	0.000633	-	0	AT
Location 3	0.005	0.002 - 0.010	0.000632	0.7	8	NSS	0 - 0.004	0.000632	0.6	1	CT
	ND	0 - 0.003	0.000632	-	0	ND	0 - 0.003	0.000632	-	0	AT
Location 4	0.009	0.005 - 0.016	0.000625	0.8	15	NSS	0 - 0.007	0.000625	0.2	4	CT
	NSS	0 - 0.005	0.000625	19	2	NSS	0 - 0.004	0.000625	19	1	AT
Location 5	0.020	0 - 0.046	0.000652	35	31	0.006	0.002 - 0.012	0.000652	35	9	CT
	NSS	0 - 0.004	0.000652	0.1	1	ND	0 - 0.003	0.000652	-	0	AT

\*\* No mean value is reported when fewer than 5 fibers were detected in the portion of sample examined.

ND = No Fibers Detected

NSS = Not Statistically Significant (1 to 4 fibers detected)

\*CT = Total Chrysotile Fibers plus Bundles

\*AT = Total Amphibole Fibers plus Bundles

\*NAM = Non-Asbestos Mineral Fibers plus Bundles

\*MMF = Man Made Mineral Fibers plus Bundles

TABLE 15 SUMMARY OF RESULTS OF ANALYSES FOR ASBESTOS

WAIKEGAN LANDFILL AMBIENT ASBESTOS MONITORING

RUN 2 - 24 OCTOBER 1984

Job Number 84487

Sample Description	FIBERS OF ALL LENGTHS					FIBERS GREATER THAN 5.0 MICROMETERS IN LENGTH					Fiber Type *
	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	
	Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			
<u>OFF-SITE SAMPLES</u>											
Location 1				S A M P L E   N O T   A V A I L A B L E							CT AT
Location 2	NSS	0 - 0.004	0.000540	0.009	2	ND	0 - 0.002	0.000540	-	0	CT
	NSS	0 - 0.004	0.000540	4.7	2	ND	0 - 0.002	0.000540	-	0	AT
Location 3	ND	0 - 0.003	0.000723	-	0	ND	0 - 0.003	0.000723	-	0	CT
	NSS	0 - 0.004	0.000723	0.05	1	ND	0 - 0.003	0.000723	-	0	AT

\*\* No mean value is reported when fewer than 5 fibers were detected in the portion of sample examined.

ND = No Fibers Detected

NSS = Not Statistically Significant (1 to 4 fibers detected)

\*CT = Total Chrysotile Fibers plus Bundles

\*AT = Total Amphibole Fibers plus Bundles

\*NAM = Non-Asbestos Mineral Fibers plus Bundles

\*MMM = Man Made Mineral Fibers plus Bundles

TABLE 16 SUMMARY OF RESULTS OF ANALYSES FOR ASBESTOS

## WAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING

RUN 3 - 29 OCTOBER 1984

Job Number 84487

Sample Description	FIBERS OF ALL LENGTHS					FIBERS GREATER THAN 5.0 MICROMETERS IN LENGTH					Fiber Type
	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	
	Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			
<u>ON SITE-SAMPLES</u>											
Location 1	0.006	0.003 - 0.011	0.000552	0.09	11	NSS	0 - 0.004	0.000552	0.02	1	CT
	NSS	0 - 0.004	0.000552	0.3	1	ND	0 - 0.003	0.000552	-	0	AT
Location 2	0.003	0.001 - 0.008	0.000571	0.07	6	ND	0 - 0.003	0.000571	-	0	CT
	NSS	0 - 0.005	0.000571	0.01	2	ND	0 - 0.003	0.000571	-	0	AT
Location 3	0.003	0.0008- 0.007	0.000547	0.02	5	ND	0 - 0.003	0.000547	-	0	CT
	NSS	0- 0.006	0.000547	0.07	4	ND	0 - 0.003	0.000547	-	0	AT
Location 4	0.004	0.001 - 0.009	0.000566	0.3	7	ND	0 - 0.003	0.000566	-	0	CT
	NSS	0 - 0.005	0.000566	0.1	3	ND	0 - 0.003	0.000566	-	0	AT
Location 5	0.006	0.002 - 0.012	0.000608	0.04	10	ND	0 - 0.003	0.000608	-	0	CT
	NSS	0 - 0.006	0.000608	0.4	3	ND	0 - 0.003	0.000608	-	0	AT

\*\* No mean value is reported when fewer than 5 fibers were detected in the portion of sample examined.

ND = No Fibers Detected

NSS = Not Statistically Significant (1 to 4 fibers detected)

\*CT = Total Chrysotile Fibers plus Bundles

\*AT = Total Amphibole Fibers plus Bundles

\*NM = Non-Asbestos Mineral Fibers plus Bundles

\*MM = Man Made Mineral Fibers plus Bundles



TABLE 17 SUMMARY OF RESULTS OF ANALYSES FOR ASBESTOS

HAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING

RUN 3 - 29 OCTOBER 1984

Job Number 84487

Sample Description	FIBERS OF ALL LENGTHS					FIBERS GREATER THAN 5.0 MICROMETERS IN LENGTH					Fiber Type
	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	
	Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			
<u>OFF-SITE SAMPLES</u>											
Location 1	NSS	0 - 0.005	0.000606	0.06	2	ND	0 - 0.003	0.000606	-	0	CT
	NSS	0 - 0.007	0.000606	0.2	4	ND	0 - 0.003	0.000606	-	0	AT
Location 2	0.003	0.001 - 0.009	0.000690	0.03	5	ND	0 - 0.003	0.000690	-	0	CT
	NSS	0 - 0.008	0.000690	0.2	4	ND	0 - 0.003	0.000690	-	0	AT
Location 3	NSS	0 - 0.006	0.000596	0.008	3	ND	0 - 0.003	0.000596	-	0	CT
	NSS	0 - 0.007	0.000596	4.9	4	ND	0 - 0.003	0.000596	-	0	AT

\*\* No mean value is reported when fewer than 5 fibers were detected in the portion of sample examined.

ND = No Fibers Detected

NSS = Not Statistically Significant (1 to 4 fibers detected)

\*CT = Total Chrysotile Fibers plus Bundles

\*AT = Total Amphibole Fibers plus Bundles

\*NAM = Non-Asbestos Mineral Fibers plus Bundles

\*MMM = Man-Made Mineral Fibers plus Bundles

**TABLE 18 SUMMARY OF RESULTS OF ANALYSE, FOR ASBESTOS**  
**WAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING**  
**RUN 4 - 30 OCTOBER 1984**

Job Number 84487

Sample Description	FIBERS OF ALL LENGTHS					FIBERS GREATER THAN 5.0 MICROMETERS IN LENGTH					Fiber Type
	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	
	Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			
<u>OH-SITE SAMPLES</u>											
Location 1	0.003	0.0008 - 0.007	0.000536	0.2	5	ND	0 - 0.002	0.000536	-	0	CT
	ND	0 - 0.002	0.000536	-	0	ND	0 - 0.002	0.000536	-	0	AT
Location 2	NSS	0 - 0.004	0.000592	0.01	1	ND	0 - 0.003	0.000592	-	0	CT
	ND	0 - 0.003	0.000592	-	0	ND	0 - 0.003	0.000592	-	0	AT
Location 3	NSS	0 - 0.005	0.000572	0.005	2	ND	0 - 0.003	0.000572	-	0	CT
	NSS	0 - 0.005	0.000572	0.05	2	ND	0 - 0.003	0.000572	-	0	AT
Location 4	0.005	0.002 - 0.011	0.000595	0.03	9	ND	0 - 0.003	0.000595	-	0	CT
	ND	0 - 0.003	0.000595	-	0	ND	0 - 0.003	0.000595	-	0	AT
Location 5	0.008	0.004 - 0.015	0.000599	0.3	14	NSS	0 - 0.004	0.000599	0.05	1	CT
	0.004	0.001 - 0.008	0.000599	2.7	6	ND	0 - 0.003	0.000599	-	0	AT

\*\* No mean value is reported when fewer than 5 fibers were detected in the portion of sample examined.

ND = No Fibers Detected

NSS = Not Statistically Significant (1 to 4 fibers detected)

\*CT = Total Chrysotile Fibers plus Bundles

\*AT = Total Amphibole Fibers plus Bundles

\*NAM = Non-Asbestos Mineral Fibers plus Bundles

\*MMM = Man-Made Mineral Fibers plus Bundles

**TABLE 19 SUMMARY OF RESULTS OF ANALYSES FOR ASBESTOS**

**WAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING**

**RUN 4 - 30 OCTOBER 1984**

Job Number **84487**

Sample Description	FIBERS OF ALL LENGTHS					FIBERS GREATER THAN 5.0 MICROMETERS IN LENGTH					Fiber Type
	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	
	Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			
<u>OFF-SITE SAMPLES</u>											
Location 1	NSS	0 - 0.005	0.000568	0.02	3	ND	0 - 0.003	0.000568	-	0	CT
	NSS	0 - 0.004	0.000568	0.06	1	ND	0 - 0.003	0.000568	-	0	AT
Location 2	NSS	0 - 0.006	0.000583	0.01	3	ND	0 - 0.003	0.000583	-	0	CT
	NSS	0 - 0.005	0.000583	0.02	2	ND	0 - 0.003	0.000583	-	0	AT
Location 3	NSS	0 - 0.005	0.000599	0.02	2	ND	0 - 0.003	0.000599	-	0	CT
	NSS	0 - 0.005	0.000599	0.02	2	ND	0 - 0.003	0.000599	-	0	AT

++ No mean value is reported when fewer than 5 fibers were detected in the portion of sample examined.

ND = No Fibers Detected

NSS = Not Statistically Significant (1 to 4 fibers detected)

\*CT = Total Chrysotile Fibers plus Bundles

\*AT = Total Amphibole Fibers plus Bundles

‡ NAM = Non-Asbestos Mineral Fibers plus Bundles

\* MMM = Man-Made Mineral Fibers plus Bundles

TABLE 20 SUMMARY OF RESULTS OF ANALYSES FOR ASBESTOS

## WAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING

RUN 5 - 05 NOVEMBER 1984

Job Number 84487

Sample Description	FIBERS OF ALL LENGTHS					FIBERS GREATER THAN 5.0 MICROMETERS IN LENGTH					Fiber Type *
	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	
	Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			
<u>ON-SITE SAMPLES</u>											
Location 1	0.008	0.004 - 0.014	0.000525	0.3	16	NSS	0 - 0.004	0.000525	0.07	2	CT
	NSS	0 - 0.005	0.000525	0.1	3	ND	0 - 0.002	0.000525	-	0	AT
Location 2	0.039	0.017 - 0.061	0.000536	3.6	73	0.003	0.001 - 0.008	0.000536	2.1	6	CT
	0.004	0.001 - 0.008	0.000536	2.9	7	NSS	0 - 0.003	0.000536	2.4	1	AT
Location 3	0.005	0.002 - 0.010	0.000504	0.8	10	NSS	0 - 0.004	0.000504	0.6	2	CT
	NSS	0 - 0.006	0.000504	0.2	4	ND	0 - 0.002	0.000504	-	0	AT
Location 4	0.004	0.001 - 0.009	0.000545	2.3	8	NSS	0 - 0.004	0.000545	2.3	1	CT
	NSS	0 - 0.004	0.000545	0.05	2	ND	0 - 0.003	0.000545	-	0	AT
Location 5	0.027	0.011 - 0.043	0.000676	1.0	40	0.004	0.001 - 0.009	0.000676	0.4	6	CT
	0.004	0.001 - 0.009	0.000676	0.8	6	ND	0 - 0.003	0.000676	-	0	AT

\*\* No mean value is reported when fewer than 5 fibers were detected in the portion of sample examined.

ND = No Fibers Detected

NSS = Not Statistically Significant (1 to 4 fibers detected)

\*CT = Total Chrysotile Fibers plus Bundles

\*AT = Total Amphibole Fibers plus Bundles

\*NAM = Non-Asbestos Mineral Fibers plus Bundles

\*MM = Man-Made Mineral Fibers plus Bundles

**TABLE 21 SUMMARY OF RESULTS OF ANALYSES FOR ASBESTOS**

**HAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING**

RUN 5 - 05 NOVEMBER 1984

Job Number 84487

Sample Description	FIBERS OF ALL LENGTHS					FIBERS GREATER THAN 5.0 MICROMETERS IN LENGTH					Fiber Type •
	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	
	Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			
<u>OFF-SITE SAMPLES</u>											
Location 1	NSS	0 - 0.004	0.000584	0.002	1	ND	0 - 0.003	0.000584	-	0	CT
	NSS	0 - 0.006	0.000584	0.09	4	ND	0 - 0.003	0.000584	-	0	AT
Location 2	NSS	0 - 0.004	0.000579	0.001	1	ND	0 - 0.003	0.000579	-	0	CT
	NSS	0 - 0.006	0.000579	0.9	3	ND	0 - 0.003	0.000579	-	0	AT
Location 3	NSS	0 - 0.004	0.000693	0.002	1	ND	0 - 0.003	0.000693	-	0	CT
	NSS	0 - 0.008	0.000693	0.04	4	ND	0 - 0.003	0.000693	-	0	AT

++ No mean value is reported when fewer than 5 fibers were detected in the portion of sample examined.

ND = No Fibers Detected

NSS = Not Statistically Significant (1 to 4 fibers detected)

\*CT = Total Chrysotile Fibers plus Bundles

\*AT = Total Amphibole Fibers plus Bundles

\*NAM = Non-Asbestos Mineral Fibers plus Bundles

\*MM = Man-Made Mineral Fibers plus Bundles

TABLE 22 SUMMARY OF RESULTS OF ANALYSES FOR ASBESTOS

## WAUKEGAN LANDFILL AMBIENT ASBESTOS MONITORING

## EXAMINATION OF BLANK FILTERS

(Air Volume of 10.0 m<sup>3</sup> Assumed for Data Processing)

Job Number 84487

Sample Description	FIBERS OF ALL LENGTHS					FIBERS GREATER THAN 5.0 MICROMETERS IN LENGTH					Fiber Type
	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	Fiber Concentration (Fibers/mL)			Estimated Mass Concentration (Nanograms/m <sup>3</sup> )	Number of Fibers Counted	
	Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			Mean	95% Confidence Interval	Concentration Equivalent to 1 Fiber Detected			
<u>ON-SITE SAMPLES</u>											
Run No. 1, Field Blank	0.007	0.003 - 0.014	0.000711	0.04	10	ND	0 - 0.003	0.000711	-	0	CT
	NSS	0 - 0.008	0.000711	0.2	4	ND	0 - 0.003	0.000711	-	0	AT
Run No. 4, Field Blank	NSS	0 - 0.007	0.000631	0.2	4	ND	0 - 0.003	0.000631	-	0	CT
	0.006	0.003 - 0.012	0.000631	0.3	10	ND	0 - 0.003	0.000631	-	0	AT
<u>OFF-SITE SAMPLES</u>											
Run No. 2, Field Blank	0.004	0.001 - 0.009	0.000679	0.09	6	ND	0 - 0.003	0.000679	-	0	CT
	NSS	0 - 0.005	0.000679	0.05	2	ND	0 - 0.003	0.000679	-	0	AT
<u>LABORATORY BLANK</u>											
Lot Number 83Q9B51 (Same Lot Number as Filter used in Field)	0.005	0.002 - 0.011	0.000686	0.5	8	ND	0 - 0.003	0.000686	-	0	CT
	NSS	0 - 0.007	0.000686	0.04	3	ND	0 - 0.003	0.000686	-	0	AT

\*\* No mean value is reported when fewer than 5 fibers were detected in the portion of sample examined.

ND = No Fibers Detected

NSS = Not Statistically Significant (1 to 4 fibers detected)

\*CT = Total Chrysotile Fibers plus Bundles

\*AT = Total Amphibole Fibers plus Bundles

\*NAM = Non-Asbestos Mineral Fibers plus Bundles

\*MMH = Man-Made Mineral Fibers plus Bundles

**TABLE 23    MAXIMUM ASBESTOS FIBER CONCENTRATIONS**  
**ON-SITE LOCATIONS**

Asbestos Type	Run Number	Asbestos Fibers of All Lengths (Fibers/mL)		Asbestos Fibers Longer than 5um (Fibers/mL)	
		Highest Mean Value	Upper 95% Confidence Limit	Highest Mean Value	Upper 95% Confidence Limit
Chrysotile	1	0.021	0.036	0.003	0.007
	2	0.065	0.15	0.006	0.012
	3	0.006	0.012	NSS	0.004
	4	0.008	0.015	NSS	0.004
	5	0.039	0.061	0.004	0.009
	Field Blank	0.007	0.014	ND	0.003
	Lab. Blank	0.005	0.011	ND	0.003
Amphibole	1	NSS	0.005	NSS	0.004
	2	NSS	0.006	NSS	0.006
	3	NSS	0.006	ND	0.003
	4	0.004	0.008	ND	0.003
	5	0.004	0.009	NSS	0.003
	Field Blank	0.006	0.012	ND	0.003
	Lab. Blank	NSS	0.007	ND	0.003

ND = None Detected

NSS= Not Statistically Significant

**TABLE 24    AVERAGES OF UPPER 95% CONFIDENCE LIMITS OF  
FIBER CONCENTRATION FOR EACH SAMPLING RUN**

Sampling Run	Fiber Variety	Average of Upper 95% Confidence Limits of Fiber Concentration, Fiber/mL			
		Fibers of All Lengths		Fibers Longer than 5 Micrometers	
		On-Site	Off-Site	On-Site	Off-Site
1	Chrysotile	0.017	0.0050	0.0044	0.0027
	Amphibole	0.0046	0.0043	0.0034	0.0027
2	Chrysotile	0.047	0.0035	0.0068	0.0025
	Amphibole	0.0046	0.0040	0.0038	0.0025
3	Chrysotile	0.0094	0.0067	0.0032	0.0030
	Amphibole	0.0052	0.0073	0.0030	0.0030
4	Chrysotile	0.0084	0.0053	0.0030	0.0030
	Amphibole	0.0042	0.0047	0.0028	0.0030
5	Chrysotile	0.027	0.0040	0.0058	0.0030
	Amphibole	0.0064	0.0067	0.0026	0.0030
Blanks	Chrysotile	0.010		0.0030	
	Amphibole	0.0080		0.0030	



**Table 26    Level of Significance at which Uniform Fiber Deposit  
can be Demonstrated for Chrysotile Fibers plus Fiber Bundles**

Sampling Run	ON-SITE					OFF-SITE		
	Location 1	Location 2	Location 3	Location 4	Location 5	Location 1	Location 2	Location 3
Run No. 1	<0.1%	50%	50%	2.5%	25%	25%	25%	*
Run No. 2	<0.1%	25%	10%	2.5%	<0.1%	+	50%	*
Run No. 3	5%	1%	<0.1%	<0.1%	50%	50%	50%	50%
Run No. 4	0.5%	25%	50%	50%	<0.1%	50%	50%	50%
Run No. 5	<0.1%	<0.1%	10%	<0.1%	<0.1%	25%	25%	50%

+    No sample available

\*    No fibers detected

TABLE 27    AMBIENT AIR GUIDELINES FOR ASBESTOS FIBERS (after Chatfield<sup>3</sup>)

Jurisdiction	Asbestos Fiber Concentration
State of Connecticut (proposed) - 30 day Average (electron microscopy)	30 ng/m <sup>3</sup> or 30,000 total asbestos fibers/m <sup>3</sup>
Province of Ontario - 24 hour Average (electron microscopy) - 30 minute Average (weight)	40 fibers/liter (>5 µm) 5 µg/m <sup>3</sup>
Province of British Columbia (optical)	<0.04 fiber/cm <sup>3</sup>
West Germany (proposed) (electron microscopy)	1 fiber/liter (>5 µm)
Montreal Urban Community (optical)	0.05 fiber/cm <sup>3</sup>
New York City (recommended by Nicholson) (electron microscopy)	100 ng/m <sup>3</sup>
France (Conseil Supérieur d'Hygiène Publique de France proposed ambient air quality inside buildings) (electron microscopy)	50 ng/m <sup>3</sup>

RESPONSE TO COMMENTS ON ORF  
REPORT 10335 BY EPA IN THEIR LETTER OF JUNE 4 1985

DR. E. J. CHATFIELD, ONTARIO RESEARCH FOUNDATION  
25TH JUNE 1985

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SIGNIFICANCE OF MASS CONCENTRATION RESULTS

Although the EPA analytical method calls for calculation of a fiber mass concentration, using the fiber concentration, fiber dimensions and a density, the values obtained are of doubtful significance. Firstly, the main contribution to the mass measurement is made by the large diameter fibers, and all of the animal work indicates that these large diameter fibers are of less biological significance. Secondly, it has been found that there is not often a good correlation between high numerical and high mass concentrations. Thirdly, the reliability of the mass determination is very poor, particularly when there are only a few fibers as there are in most of these measurements. An examination of the data clearly indicates that where high mass concentrations are found, most of the mass is resident in one or two fibers. For example, in Run 2, Location 1, a mass concentration of 88 ng/cubic meter was found. An examination of the raw data readily shows that 90.2% of this measurement is accounted for by one fiber, whereas this fiber represents only 1.18% of the numerical concentration. Similarly, in Run 1, location 1, 78.57% of the mass concentration reported is accounted for by only 2 fibers. The mean chrysotile mass concentration quoted in the review is 6.1 ng/cubic meter: the sample estimate of the standard deviation is 18.56, three times the mean value. The mean itself is strongly weighted by three high values, and 89% of this mean is contributed by only 9 fibers.

The off-site measurement mean, without accounting for background, was 0.016 fiber/mL, with a standard deviation of 0.017 fiber/mL. Using standard statistical tests as described in NBS Handbook 91, it is not possible to demonstrate a statistically-significant difference between the on-site and off-site mass concentrations at 5% significance. Moreover, it is questionable whether the use of an arithmetic mean of the mass concentrations is in any way justified, since the data are clearly not normally distributed.

It should be recognized that in order to obtain reliable mass concentration measurements, it is necessary to apply totally different fiber counting criteria and strategy, such that the majority of the mass is accounted for in a statistically-meaningful manner. This is not the case in the EPA methodology, where the strategy is designed primarily to count numerical concentrations. The mass concentration only becomes a meaningful measurement when the maximum size of fiber found contributes only a small proportion of the total mass.

### USE OF 0.2 UM PORE DIAMETER FILTERS

The EPA analytical method specifies the use of 0.4 um pore diameter filters, because these allow a reasonable flow rate to be obtained. The only collection efficiency work performed in support of this decision has been done using mass collection efficiencies only. Other collection efficiency measurements on Nuclepore filters, specifically for fibrous aerosols, have been made by both Spurny and Chatfield. These later studies confirm that fibers align with the flow lines, and fibers longer than the pore diameter pass through the filter. Chatfield determined that the 50% collection length (that fiber length for which 50% of the fibers pass through the filter) is about double the nominal pore diameter. For example, through a 0.4 um pore diameter filter, half of the fibers shorter than or equal to 0.8 um will pass through the filter. Use of the 0.2 um pore diameter filter can only increase the collection efficiency, leading to higher fiber counts, rather than to a loss of information.

### WEATHER CONDITIONS DURING SAMPLING

The weather conditions during the sampling runs were entirely as specified in the EPA protocol for these measurements. Section 4 of Exhibit 1, "PLAN FOR ADDITIONAL MONITORING", specifically states that "In all cases, days with rain or days following precipitation by less than 24 hours should be avoided."

The wind vane and anemometer system was sited at a high point approximately 20 feet above the West side of the roof of the roofing building. The records from this instrument were provided in order to demonstrate that sampling had been conducted for a range of wind directions; use of wind speed and direction recording equipment was not called for in the EPA protocol. In view of the surrounding buildings adjacent to the disposal area, there would be substantial turbulence and variation in wind direction at different points on the site close to ground level. The local wind direction at the sampling points could only be obtained by installing a recorder at each sampling location, and this was not specified in the EPA protocol.

### BLANK MEASUREMENTS

The blank measurements obtained were characteristic of Nuclepore filters as currently available. The existence of background counts of this order on blank filters is accepted by laboratories active in this kind of analysis. The levels obtained in this work were no different from the levels found in ongoing parallel work, and there was no need for any additional confirmation that the fibers observed were present on blank filters. The significance of the blank measurement is minimized by filtration of the maximum volume of air possible during the air sampling. In this case the mean fiber concentration for the highest of the blank measurements was 7 fibers per liter, for fibers of all lengths, and less than 3 fibers per liter for fibers longer than 5 micrometers. It should be recognized that the number of fibers found on a blank filter is not necessarily the important criterion, rather the relationship which the number has to the analytical sensitivity and the actual concentration

being measured. The maximum number of fibers found on the blank filters was 10, just twice the number which is regarded as the limit of statistical significance. This level of contamination is not sufficiently high to warrant further investigation, because it is entirely within the pattern of the known current levels. It should be emphasised that no fibers longer than 5 micrometers are found on blank filters, and this is also the normal situation.

#### SIGNIFICANCE OF NON-UNIFORMITY OF FIBER DEPOSITS ON FILTERS

The comments in the ORF report concerning the non-uniformity of deposits on the filters were made in order to draw attention to what is accepted as a limitation of the analytical method, and not, as the reviewer suggests, as an "attempt to discount the significance of high on-site fiber counts". This aspect of the direct method of sample preparation is now well understood, and can be demonstrated very easily by aerosol generator studies. The comment was made in connection with the high samples simply because these are the only ones for which it can be demonstrated.

The observation that fiber counts on individual grid openings are not distributed according to a Poisson distribution leaves doubts as to the validity of the measurement. Deviations from the Poisson distribution can only be demonstrated where there is a sufficiently large number of fibers in the count. Although it can be stated that the numerical fiber counts in the inter-laboratory analyses are substantially in agreement, there are clearly some problems in the mass measurement. In the case of Run 1, Location 1, and Run 2, Location 1, the ORF measurements indicate mass concentrations of 14 and 88 ng/cubic meter respectively, values which are not confirmed by the EMS analyses. For Run 2, Location 1, in particular, the number of fibers counted in the ORF measurement (85) is sufficiently high that better agreement between the two laboratories could have been expected. In fact, in both of the inter-laboratory samples which were selected as representative of high ORF fiber counts, the mass concentration reported by EMS was substantially lower and not in agreement. It would be expected that the mass per unit area on the filter would be constant for both laboratories if the filters displayed a uniform deposit.

TABLE 25 AVERAGES OF UPPER 95% CONFIDENCE LIMITS OF  
FIBER CONCENTRATION FOR ALL SAMPLING RUNS

Fiber Variety	Samples	Average of Upper 95% Confidence Limits of Fiber Concentration, Fiber/mL	
		Fibers of All Lengths	Fibers Longer than 5 Micrometers
Chrysotile	On-Site (25 Samples)	0.022	0.0046
	Off-Site (14 Samples)	0.0049	0.0028
	Blanks (4 Samples)	0.010	0.0030
Amphibole	On-Site (25 Samples)	0.0050	0.0031
	Off-Site (14 Samples)	0.0054	0.0028
	Blanks (4 Samples)	0.0080	0.0030